THE
HOME TEACHER

A CYCLOPÆDIA OF
SELF-INSTRUCTION

EDITED BY

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ENGLISH LITERATURE.—CHAPTER VII.

THE DRAMA—MYSTERIES, MIRACLES, AND MORALITIES—EARLY PAGEANTS AND CITY AMUSEMENTS—REPRESENTATIVE LITERATURE—TRAGEDY AND COMEDY—THE PREDECESSORS OF SHAKSPEARE.

That species of poem in which a narrative or action is not related but represented, is called the *Drama* (Gr. δρκω, I do or act). Life takes, in all human experience, the historic form. This fundamental conception underlies dramatic composition as an artistic product, gratifying at once eye, ear, intellect, sympathy, curiosity, and moral expectancy, by its representation of the eventful and interesting incorporated in the beautiful. Life idealized and imitatively represented constitutes its charm. It is a poetic product of the imagination, and is, in more than one sense, recreative. The picturesque, passionate, and active life of man is by the dramatist deftly woven into poetry—the pleasantest power of speech. By him thought is shown in operation, passion in progress, emotion emerging into energy, and man's nature is made transparent from inner core to outer gesture. Great men signalize themselves in events, events emphasize themselves in history, and history is vivified in the drama. The dramatic method is an organic one—a complex whole, consisting of poetry, painting, music, oratory, sculpture, and action, made one in sequence and issue by the compulsive energy of genius. Literature, however, leaves action as an art to the stage, and considers chiefly the diction of the written page.

The dramatic tendency is inborn in man. He is reproductively imitative in conversation, narration, song, and ballad. The drama is not wholly a pastime for an idle hour. It is a vital development of the intellectual powers of some great mind, and it appeals to the higher capacities and emotions of men. The drama of Christendom also received vitality from the desire to promulgate didactically the formulas of faith. In the "Concilium Provinciale Scoticorum," held in the reign of Alexander II., penalties are decreed against all who desecrate either the church or the churchyard by the performance of plays therein. The earliest religious drama was brought over the sea by the ecclesiastics who came in with the Conqueror, though we have indications of the performance of Latin literary plays under the Romans in the grammar schools. These were intellectual, not popular diversions, on which account they were called plays. In *Mysteries* there were represented to the people the incidents of Scripture history; *Miracles* gave vivid delineations of the legends of the Christian church; and *Moralities*, in allegories and parables, reproduced lessons for the masses in truth and righteousness. The *Corpus Christi* plays, the spectacular pageantry of the London *Miracles* performed on saints' days, the Towneley, Coventry, and Chester plays, and the numerous interludes acted on holidays and festivals, show that the "quaint games" of the populace had a considerable dramatic tendency. Several of these early mimetic productions still survive. There are thirty-two in the Towneley, forty-two in the Coventry, and twenty-five in the Chester series; and interludes are numerous. Of these latter, "The Castle of Perseverance," "Mind, Will, and Understanding," &c., are found in the Digby MSS. Thus were—

"In pageants set forth, apparently to alle eyne,
The Old and New Testamente with livilye comforte;
Intermingling therewith—only to make sporte—
Some things not warranted by any writ."

Persons of austere piety, or professors of superior sanctity, boasted, like the friar minor in "Piers Ploughman's Crede,"

"We haunten no tavernes, ne hobelen abouten,
At markettes and miracles we meddley us never;"

and, like the satirist in Henry VI.'s time, mourned that

"Inglande goith to nought—*plus fecit homo viciosus*,
To lust man is brought—*nimis est homo deliciosus*;
Goddis holidays—*non observantur honeste*,
For unthryftye playis—*in eis regnant manifeste*."

This shows how finely characteristic is Chaucer's making "The Wife of Bath" during Lent amuse herself by going

"To preachinges and to those pilgrimages,
To playes of miracles and to marriáges."

One of the earliest moral plays in the English language, which attained the honour of type (1519), is "A Newe Interlude and a Merry of the Nature of the Four Elements," which is also an attempt to popularize science on the stage. A messenger, as prologue, opens the piece and shows what advantage must accrue if "all subtle science in English might be learned." Nature, Humanity, Studious Desire, Sensual Appetite, a Taverner, Experience, and Ignorance, are the *dramatis personæ*. This discourse on physiography and morality in verse, which the compiler says "is with rhetoric not adorned," closes abruptly, as if it were to allow additions of a local or temporary interest to be made to what had been written. "The Marriage of Wit and Science"—which was printed about 1570—is a moral play of a similar sort, though higher in tone and superior in poetical power and sententious humour. The characters are—Nature and her sons, Wit, Will, Study, Science, Reason, Experience, Recreation, Diligence, Instruction, Shame, Idleness, Ignorance, and Tediousness. Reason and Experience are the parents of Science; Will is Wit's servant; Study, Diligence, and Instruction became his tutors; he is inveigled by Idleness and Ignorance into the toils of Tediousness, by whom he is wounded; Recreation somewhat restores him; but Shame saddens him for his folly. At last Tediousness is slain, and Wit and Science are betrothed, the former saying:—

"We twain, henceforth one soul, in bodies twain must dwell."

It is pleasing—when Bacon was nine and Shakspeare six years of age—to find Science addressed thus:—

"O pearl of passing price, sent down from God on high,
The sweetest beauty to entice, that hath been seene with eye;
The well of wealth to all, that no man doth annoy;
The key of kingdoms and the seal of everlasting joy.
The treasure and the store whence all good things began,
The nurse of Lady Wisdom's love, the link of man and man."

The popularity of such ideas is seen in the fact that the allegory of this production is to some extent borrowed from "The playe of Wyt and Science, made by Master John Redford," in the time of Henry VIII., printed for the Shakspeare Society (1848); and that for the same society there was printed in 1846, from an old MS., an "Interlude on the Marriage of Wit and Wisdom," of which, though printed in 1579, no copy now survives.

A very meritorious morality of these olden days is "The Worlde and the Chylde," which issued from the press of Wynkyn de Worde in 1522. Mundus, "ruler of rulers," "prince of power and plenty," is addressed by Infans—whose mother is called Dalliance—"poorly picked in poverty." He comes to "crave meat and clothes my life to save." The World grants his request "till fourteen years be come and gone," and gives him the new name Wanton. The child rejoices in his fresh life, learns all sorts of games, and plays all manner of mischief. He then returns to "the World, the worthy Emperor," who confers on him the new name, Love-lust, Liking. "As fresh as flowers in May," "seemly shapen," "proudly apparelled in garments gay," and "full lovely to a lady's eye," he enjoys his youth, "till one and twenty winters is comen and gone." Then he goes to "the World," a higher science to assay. Mundus calls him Manhood-mighty, and sets him to serve the seven sovereigns of the earth—Pride, Envy, Wrath, Covetousness, Sloth, Gluttony, and Lechery. Manhood knighted, endued with grace and beauty, strength and might, furnished with gold, silver, and a sword, goes forth to seek adventures. He finds them in many lands, and boasts of his success. Conscience, who knows "all the mysteries of man," beseeches every one for Christ's sake to take his counsel. Manhood mocks and scorns him. Listening to his talk, however, Manhood is almost persuaded to "clean forsake the kings of sin," when Folly, whose ancestry is English and himself London-born, enters singing his "Heigho!" After a lively conversation

Manhood, overcome by Folly, casts Conscience off. Conscience asks help from his born-brother Perseverance to save Manhood, who has now acquired the name of Shame. They meet him—now surnamed Age—wandering weakly "as a wight in woe and care," and give him a new name, Repentance. They supply him with theological teaching, and—when he accepts it "in the spirit of my soul" as "true"—Perseverance, "through the grace of God Almight," prays "Jesus, maker of all," to cover men "with his mantle perpetual."

A number of these anonymous dramatic dialogues and sketches—like "Calisto and Mylibæa"—"an interlude showing the beauty and good properties of women"—may be, for the age, characterized as "right elegant and full of crafte of rhetoric." "Everyman" involves a very striking idea. God calls Death to bring Everyman into his presence. Everyman is appalled, and calls on Kindred, Fellowship, Goods, and Riches for help. They fail him. He goes to Good Deeds, who—though upbraiding him with previous carelessness—introduces him to Knowledge, by whom he is brought to Confession and Penance. Thus he is reconciled to the church. Strength, Beauty, Discretion, and Wits leave him; Good Deeds remaining with him till he expires, and an angel sings his *requiem*. "Hickscorner" gives a humorous exposure of some of the common vices of the time, and shows how Pity and Perseverance succeed in reclaiming men from the evil courses into which they are led by Freewill and Imagination. Most of these plays had "a moral conclusion and an exhortation to virtue." For instance, "Thersites"—an interlude, in the epilogue of which the lovely Lady Jane [Seymour] and the Prince (afterwards Edward VI.), born 12th August, 1537, are prayed for—"doth declare howe that the greatest boasters are not the greatest doers." "The Interlude of Youth" exhibits how Youth is tempted by Pride and Passion, and how both of these are defeated by Charity and Humility; and "Nice Wanton" (1560) is one

> "Wherein we may see Three branches of an ill tree;
> The mother and her children three, Two naught and one godlye,
> Early sharp that will be thorn, Soon ill that will be naught;
> To be naught is better unborn, Better unfed than naughtly taught."

Xantippe, a scold, is the mother; Ishmael and Delilah are the two naught, who "end their lives in miserable wise;" Barnabas is the one godlye "son of Consolation;" and Daniel is the judge who dooms Ishmael.

In the time of Stephen an English monk, Hilarius, who was a pupil of Abelard's, wrote, in France, three miracle plays—"St. Nicholas," "The Raising of Lazarus," and the "History of Daniel." Ralph Higden of St. Werberghs', Chester (author of the "Polychromion"), who travelled thence to Rome to ask permission to use English in the teaching of religion, has been credited with the authorship of the Chester mysteries, which retained their popularity as folk-shows for four centuries. "The Castle of Perseverance" (of date 1450 or so) is one of the oldest moralities extant, but is anonymous. An old English mystery, in MS. of date 1512, on Mary Magdalene, is in the Bodleian Library. It was printed in Edinburgh in 1835. Another "Interlude entreating of the Life and Repentance of Marie Magdalen," "made by the learned clerk Lewis Wager," was printed at London, *anno* 1567, in which year also "The Trial of Treasure," directed against the vanity of riches, appeared in type. In a great majority of these dramatic efforts the Vice, who is the antagonist of evil, impersonated often as Satan, formed one of the chief characters, wielding his dagger of lath, wearing enormous spectacles, and flaunting long loose robes, greatly to the delight of the spectators. In the play of "Common Conditions" the name-hero of the piece, whose adventures with Thrift, Drift, and Unthrift are pretty humorous, is the Vice. It was the *rôle* of the formal Vice to be as amusingly mischievous as he could.

John Skelton, who has already been mentioned as the author of "Magnificence" and "Nigramansar," produced the "Morality of Virtue;" the "Interlude Academios" and (recently) the "Trial of Treasure" have been attributed to him. The brother-in-law of Sir Thomas More, John Rastall, printer, mathematician, philosopher, and theologian, is credited with the authorship of "The Four Elements" and "Gentleness and Nobility," in the latter of which he advocates the gentleness of manliness and the nobility of industry and worth when compared with mere birth and affluence. John Bale, born 21st November, 1495, at Cove, near Dunwich in Suffolk, of poor parents, became a member of the Carmelite monastery in Norwich, and proceeded thence to Holm, near Alnwick, as a monk and qualified as a priest. Under the influence of Lord Wentworth he renounced Romanism, married, and was much persecuted. Thomas Cromwell during his lifetime shielded him, and on Cromwell's death Bale fled to the Netherlands, where he remained till Edward VI. began his reign. Then he was made vicar of Bishopstoke, near Southampton. In 1552, having, despite a severe illness, welcomed Edward to Southampton, the king appointed him Bishop of Ossory. On reaching his diocese, he exerted himself in favour of the new form of faith, and was again exposed to peril of limb and life, from risk of which, on Mary's accession, he escaped to Holland, whence he proceeded to Switzerland. On his return, after Elizabeth had got firmly seated, in 1560, he was appointed to a prebendal stall in Canterbury, which he held till his death four years thereafter. He was the author not only of the earliest biographical record of British authors, "Scriptorum Illustrium Majoris Britanniæ quam nunc Angliam et Scotiam Vocant Catalogus;" "The Pageant of Popes;" "The Acts of English Votaries," an account of the monasteries of Britain; and a "Chronicle of the Examination and Death of Lord Cobham" [Sir John Oldcastle], but of eighty-five other works. He translated the Latin drama "Pammachius," which was performed at Christ's College, Cambridge, and was presented to the Privy Council for censure by Bishop Gardiner, because he thus made open some strictures on the Catholic faith and ritual. His comedy of "John the Baptist," and his tragedy of "God's promises to Men," attracted Cromwell's attention, and were often played on Sunday afternoon by the youths of Kilkenny at the market-cross. His "Three Laws of Nature, Moses, and Christ" was highly popular, and often reprinted. He gives, in a catalogue of his works, the names of nineteen plays—eleven founded on New Testament incidents, several on Old Testament ones, and some on miscellaneous themes. His best known dramatic work is "Kynge Johan," in which mention is made of John's charities to Bale's native place:—

> "Greate monumentes are in Yppeswych, Donwyche, and Berye,
> Which noteth hym to be a man of notable mercyé."

The spirit of the play is emphatic against the Roman ritual, in defiance of the Pope, in favour of Calvin's doctrines and the sovereign's authority in church and state. In it England is represented as a widow; the nobility, clergy, civilians, and the commonalty are also personified: Sedition (Stephen Langton, archbishop of Canterbury), Dissimulation (Raymond IV. of Toulouse, the brother-in-law of John), Private Wealth (Cardinal Pandulphus), Usurped Power (Pope Innocent III.), and Imperyall Majestie (Henry VIII.), who comes in to round off all by an epilogue. The history of "John Lackland's" reign is rather moralized than reproduced, and Magna Charta is unnoticed. Neither the author of "The Troublesome Reign of John, king of England," nor Shakspeare, seem to have been indebted to "bilious Bishop Bale" in their productions, though they took up and worked upon the idea of chronicle histories.

Merry John Heywood, better known as the epigrammatist, was an early dramatist. He was born at North Mims, near St. Albans, about 1506, studied at Oxford, and was a neighbour and friend of Sir Thomas More. As a zealous Catholic he suffered for his faith. In his poem of "The Spider and the Flie," in the octave stanza, Queen Mary is a housemaid who uses her broom (the civil sword) in the execution of the commands of her master (Christ) and her mistress (the church), both against the flies (Roman Catholics) and the spiders (Protestants), when they become disturbers of the comfort of the commonwealth. It does not appear to show much of "the mirth and quickness of his conceits" that "smoothed the brow of Henry [VIII.] and relaxed the rigid muscles of the melancholy Mary." Dr. Thomas Wilson, in his "Rhetorique" (1553) mentions Heywood's "Proverbs,"

and thinks that his "paynes in that behalfe are worthye of all prayse." His quirks and quibbles are seen in his "Merry Playe between a Pardoner and a Freere, the Curate and neybour Pratte," in ridicule of monkery and relic-reverence; in "Johan the Husband, Tyb the Wyf, and Sir Johan the Preest," a caricature of the disturbing influence of the regular clergy in the domestic life of the rural districts in pre-Reformation times; and in the "Four P's"—Palmer, Pardoner, Poticary, and Pedlar—four knaves, the first of whom boasts that he has seen all the world and visited numerous shrines. The second asserts that he might have saved himself all that trouble—

> "For at your dore myselfe doth dwell,
> Who could have saved your soul as well
> As all your wyde wanderings shall do,
> Though ye went thrice to Jericho."

The third claims a share of man's esteem because he fills heaven with inhabitants; and the fourth affirms that as he carries about with him trinketry tokens of love—

> "Who lyveth in love, and love would wynn,
> Even at this pack they must begynne."

They then engage in a contest as to who can tell the greatest lie, and the Palmer "bears the gree" for this one—

> "I never sawe nor knewe, on my conscience,
> Any woman out of patience."

In these, as well as in his "Play of Love," "Play of the Weather," &c., most of which appeared before 1534, Heywood makes great use of low incident and vulgar ribaldry, but fills his stage with representations (rather exaggerated) of familiar life and the popular manners of his age. On Mary's death John Heywood left England, settled at Mechlin in Brabant, where he died in 1578. His son, Jaspar Heywood, born 1535, was a fellow of Merton College, and translated "Thyestes," "Troas," and "Hercules Furens," published separately, and subsequently issued along with "Œdipus," by Alexander Neville; "Hippolytus," "Medea," "Agamemnon," and "Hercules Œteus," by John Studley; "Octavia," by Thomas Nuce; and "Thebais," by Thomas Newton, in "Seneca; his Tenne Tragedies, translated into English" in 1581. Fuller says Jaspar Heywood was executed in 1585, but Sir Richard Baker asserts that he was exiled, and Collier states that he died at Naples, 9th January, 1598.

William Fallonius, of the Hague in Holland, in 1529, produced a play in Latin, on the "Story of the Prodigal Son." This was translated, in 1540, by John Palsgrave, arranged for study as a book for use in grammar schools, with such marginal notes and useful introductory explanations of the "Kynde of Spekyng used of the Latyns," as might "leade theym more easilye to see howe the exposytion gothe." Thomas Ingelend, late student in Cambridge, produced in the reign of Henry VIII. the interlude of "The Disobedient Child," which was not printed till 1560. It shows taste, judgment, and a power of poetical picturesqueness somewhat unusual in such productions. A rich Londoner's son, disregarding the worldly-wise instructions of his father, pursues the path of self-will, and consummates his folly by an early and hastily entered into marriage with a pretty shrew. In an exhibition of the sorrows wrought by self-will, the lesson of the value of self-denial is rather suggested than expressed. Ulpian Fulwell (born 1530) author of a volume of prose and verse concerning "the bright renown and most fortunate reign of Henry VIII.," also produced a moral play called "Like will to Like," in which, through the adventures of Nichol Newfangle, the woes arising from "riotous living" are shown, in order that (as the prologue states)—

> "To what ruin ruffians and roisters are brought,
> You may here see of them the final end:
> Begging is the best—though that end be naught,
> But hanging is the woorse, if they do not amend;
> The vertuous life is brought to honour and dignitie,
> And at the last to everlasting eternitie."

Thus early England came to possess a popular form of amusement aiming at representing life in forms combining the practical and the poetical. There came afterwards into the forces of history the new learning, the fresh faith, and those wondrous developments of enterprise and adventure which made the unreading public eager to know and feel the impulses and principles through which the joy of intelligence might be theirs. An interest in history and life, which had never thrilled the heart before, was awakened among men, and the stage came to be the grand national educator of that age. It made books live, history real, and thought vital—

> "For things in motion sooner catch the eye
> That what not stirs."—*Troilus and Cressida*, III. iii.

In a brief sitting of two hours men saw the acts and learned the thoughts which history, even at its best, merely stated or related. Community of joy and feeling, of seeing and knowing, welded into oneness the citizenry, for—

> "In such business
> Action is eloquence, and the eyes of the ignorant
> More learned than their ears."—*Coriolanus*, III. iii.

The historical past could be read in the printed page of Fabyan's "Concordance of Histories," but by the drama the past itself could be immediately imprinted on the seeing eyes, the throbbing heart, the living mind. Thomas Sackville, Lord Buckhurst, lord treasurer to Queen Elizabeth and Earl of Dorset in James I.'s reign, who planned "The Mirror for Magistrates" (*i.e.* rulers)—the induction to which affords us the most characteristic product of his genius—also inaugurated the design of making plays "the abstract and brief chronicles of the time" by his "Ferrex and Porrex" (sometimes called, after the king their father, "Gorboduc"), which was performed at Whitehall before Queen Elizabeth and her court, 18th June, 1561. It was written for and played by the Society of the Inner Temple, and Thomas Norton (a weakish metrist) assisted him in part in this production, which was unauthorizedly printed in 1565, and authentically produced in 1570. It is the first example of the employment of theatrical illusions for the representation of British history, and is the earliest English drama written in blank verse. "The woeful end of Brutus' royal line" is made the groundwork of a warning against divisions in the state, and an inducement to submission to lawful authority—

> "For right will last and wrong cannot endure."

"Appius and Virginia," by R. B., deals with a favourite classical topic simply and effectively. "Cambyses, king of Persia"—written probably by Thomas Preston, subsequently master of Trinity Hall, Cambridge, in Old English Alexandrines—woke up a story from Herodotus and Justin, not without merit, though expressed in such a style as to have given rise to the Shakspearian phrase for ranting verbiage—

> "I must do it in passion,
> And I will do it in King Cambyses' vein."
> —*Henry I.*, II. iv.

The following is a specimen:—

> *King.*—"Thou cursed Jill, by all the gods I take an oath and swear,
> That flesh of thine these hands of mine in pieces small could tear;
> But thou shalt die by dint of sword, there is no friend, ne fee
> Shall find remorse at prince's hand to save the life of thee.
> . . . .
> *Queen.*—Your Grace doth know by marriage true I am your wife and spouse,
> And one to save another's health (at troth plight) made our vows,
> Therefore, O king, let loving queen at thy hand find remorse,
> Let pity be a mean to quench that cruel raging force."

Richard Edwards—a Somerset man, born about 1523, and educated at Corpus Christi, Oxford—to whom we owe "The Paradise of Dainty Devices," was the author of a [lost] play "Palamon and Arcyte," founded on Chaucer's "Knight's Tale," performed before Queen Elizabeth, 2nd September, 1566, as well as of an extant one, on "the two excellentest freendes" "Damon and Pythias," printed in 1571. Though Thomas Twine speaks of him, in an epitaph, as "the flower of our realm, and phœnix of our age," and Puttenham thought Edwards deserved "the highest prize for comedy and interlude," his metre is clumsy and

unmusical, and he is tiresome as well as coarse, though the prologue assures us that he has endeavoured, like Horace,

"Which hath our author taught at school, from whom he doth not swerve
In all such kind of exercise, decorum to observe."

A tragedy on "Julyus Sesar" was produced 1st February 1562, and in the same year we learn from Arthur Brooke that a drama on the story of "Romeo and Juliet" had been "lately set forth on the stage." "Scipio Africanus" was an old play when on "the Sundaye night after newe yeares daie," in 1580, it was "enacted by the children of Pawles." Stephen Gosson, author of "The Schoole of Abuse" (1579) exempts from his censorious dispraise of dramas a play entitled "Ptolemy," performed at The Bel Sauvage, and confesses that in his sallet days he composed "Catiline's Conspiracies," a subject which was subsequently taken up by Robert Wilson and Henry Chattle, 1598; by Ben Jonson, 1611; and George Croly, 1822. He also mentions "The History of Cæsar and Pompey," often dramatized, and "The Fabii," which was perhaps "The four sons of Fabyous," enacted by the Earle of Warwick's servants, at Whitehall, on "Newe Yeares daie, at night," 1579–80. Gascoigne's "Jocasta" is a free sort of composite from the "Phœnissæ" of Euripides and the "Giocasta" of Lodovico Dolce. In its preparation for Gray's Inn, 1566, he had the help of Francis Kinwelmershe and Christopher Yelverton. In the same year Gascoigne supplied Gray's Inn with considerable amusement by a prose adaptation of Ariosto's *I Suppositi*, "The Changelings," a compound of the plots of Terence's "Eunuch" and of Plautus' "Captives," to which he gave the title of "The Supposes." The plot is healthy and humorous, though Gascoigne might easily have purified it a little, and brought it nearer to the charming grace of Ariosto's style. This, though the earliest comedy written in English prose, was not the first comedy presented to the English public. That was given to our literature by the famous scholar and schoolmaster Nicholas Udall, author of "The Floures for Latine Speakynge" (1533), selected and gathered out of Terence and the same translated into Englysche, from which Shakspeare quotes in "The Taming of the Shrew," i. 1. Udall was born in Hampshire (about 1506), probably at Wykeham, entered Corpus Christi, Oxford, June, 1520, took B.A. 1524, and in 1526 was refused his M.A. on account, it is likely, of his Lutheran opinions. He was appointed head master of Eton, and gained his M.A. in 1534. Offended at being examined for complicity in the theft of some images from the chapel of the college, 1540–41, he left Eton and retired to a vicarage at Braintree in Essex. He was one of the servants of Catharine Parr at Henry VIII.'s court, was made a prebendary of Windsor by Edward VI., and head master of Westminster School, 1555, but died and was buried in Westminster, 1557. He edited, at the request of Queen Catharine Parr, Erasmus' "Paraphrase of the Four Gospels," of which he translated St. Luke. His version of Peter Martyr's "Treatise on the Lord's Supper" was dedicated to "Sir William Parre, knight, Lord Parre, Erle of Essex, Marquess of Northampton, lord great chamberlain of England," the queen's brother. Bale mentions his "Tragedy of Popery," and Dr. Thomas Wilson quotes, from "an interlude made by Nicholas Udall," lines capable of a double sense, which were found in a pamphlet destitute of a title-page, discovered in 1878 by the Rev. T. Briggs, who, as an old Etonian, presented it to the Eton College Library. That unique book is a copy of a play entered on the register of the Stationers' Company as licensed to Thomas Hacket, entitled "Ralph Roister Doister." Like an older interlude, "Jacke Juggler" —which is derived from Plautus' tragi-comedy of "Amphytryon"—this play is modelled after the comedies of Plautus and Terence, and is designed to expose vain-gloriousness. Its mirth arises from the broad farce of the courtship of Dame Custance by the foppish Master Ralph, who is cunningly duped by Matthew Merrygreek, and is, after a thorough discomfiture, constrained to consent to the lady's marriage with Gawin Goodluck; and great merriment is occasioned by a free fight among the characters, male and female. The names of the minor personages are very expressive; as, Madge Mumblecrust, Tibet Talkapace, Sim Suresby, Dobinet Doughty, Annot Alyface Truepenny, and Tristram Trusty. Of the character of Ralph, Merrygreek gives us this outline:—

"In these twenty towns, and seek them throughout,
Is not the like stock, whereon to graff a lout;
All the day long is he facing and craking
Of his great acts in fighting and fray-making,
But when Roister Doister is put to the proof,
To keep the King's [or Queen's] peace is more for his behoof;
If any woman smile, or cast on him an eye,
Up is he to the hard ears in love *by and by* (=at once).

. . . .

Hold by his yea and nay, be his own white son,
Praise him and rouse him well, and ye have his heart won,
For so well liketh he his own fond fashions
That he taketh pride of false commendations."

That Udall's reputation as a playwright was considerable we may infer, for the authorities of Cambridge University, on the queen's visit, 8th August, 1564, chose an English play, called "Ezekias," made by Mr. Udall, and handled by King's College men only "for her entertainment." "Ezekias," however, is not extant.

Prior to 1818 "Gammer Gurton's Needle" had the credit of being our first English comedy. John Still, its reputed author, born about 1543, educated at Christ's College, Cambridge, and Master of Arts in 1565, became rector of St. Martin, Outwich, London, in 1570. He subsequently rose to be canon of Westminster, master first of St. John's, and second of Trinity Hall, Cambridge. He at last was made bishop of Bath and Wells (1592–93), and dying in the episcopal palace, 26th February, 1607–8, was buried in the cathedral. It is the only drama we have from the prelate's pen, and was "played on the stage, in Christ's College, Cambridge" (1566), though it appears to have been composed in Still's undergraduate days. Its story is, that old Gammer Gurton, while mending her servant Hodge's breeches, lost her needle—hers being the only one in the parish; Diccon, the bedlam, a waggish mischief-maker, persuades her that her gossip, Dame Chat, has found the housewife's treasured implement. A search is instituted, a fray arises, words and blows call for the interference of the authorities. In the midst of the fast and furious fun Diccon hits Hodge on the hip. He howls, for the needle has gone into him like a goad. All merrily ends with a general invitation, "Let us go in and drink." Of another play, in the Devonshire MS. collection, bearing date 1577, J. P. Collier gives an account in his "History of Dramatic Literature," vol. ii., p. 468, and for this he thinks an earlier date may be assigned than to Still's comedy. It is entitled "Misogonus"—apparently after the Greek comedy of Menander, "Misogonos," The Woman Hater —and was written by Thomas Rychards—perhaps the monk of the Abbey of Tavistock, who was educated at Gloucester College, and translated into [rather archaic] English verse Boethius' "Consolations of Philosophy," at the suggestion of Robert Langton (1525). This comedy, like Gosson's "Captain Mario," and many other early plays, looks like "a cast of Italian devices." An Italian influence, derived from Machiavelli's "Belphegor," is traceable in the curious old comedy of "Grim, the Collier of Croydon," which, though no printed copy is extant prior to 1662, was evidently written, and even performed, almost a century earlier, for "Grim the Collier" is, in Edward's "Damon and Pythias" (1566), taken to the court of Dionysius in Sicily, and there, most anachronistically, sings "bass busse" and talks French. Besides, in the "One and Thirty Epigrams of Robert Crowley, vicar of St. Giles, without Cripplegate" (which was printed 1550), is one on "The Collier of Croydon" a character plainly, popularly known as a laughing-stock. The initials of the author are given as J. T. Founded on an Italian novel, probably Boccaccio's "Decameron" (iv. 1), we have the remarkable Old English tragedy, "Tancred and Gismunda"—originally composed in rhyme by five members of the Inner Temple, and acted before Queen Elizabeth in 1568. Of this form several MSS. exist, but in 1591 it was printed as "newly revived and polished [into blank verse] according to the decorum of these daies," by Robert Wilmot, then vicar of Horndon-on-the-Hill, Essex,

who excuses his publication of it, being in holy orders, by the consideration "that neither the thrice reverend and learned M. Beza was ashamed in his younger years to send abroad in his own name his tragedy of 'Abraham['s Sacrifice,' of which a very faithful translation by Arthur Golding was printed by Vautroullier in 1577], nor that even Scot (the scholar of our age) Buchanan his most pathetical 'Jephtha'" [which was published at Paris (1544), imitated both in Latin and Greek by John Christopherson, one of the first fellows in Trinity College, Cambridge, and afterwards bishop of Chichester, about the year 1546, and followed in a play written by Anthony Munday and Thomas Dekkar for Philip Henslowe in 1602].

From Giraldi Cinthio's "Hecatommithi" (viii. 5), George Whetstone, a poet, dramatist, and miscellaneous writer, whose life was one of great variety and misadventure, took the plot of "Promus and Cassandra." He claimed kindred with Sergeant Fleetwood, recorder of London, sought a place at court, served abroad as a soldier, and was an eye-witness of Sir Philip Sidney's fall at Zutphen. After a little farming, he sailed with Sir Humphrey Gilbert in his expedition to Newfoundland, and on his return gave himself to literary labour, with but poor pecuniary results. From an allusion in Ben Jonson's "Bartholomew Fair" it has been inferred that he died in Bedlam. It does not appear that "Promus and Cassandra," printed 1578, was ever placed on the stage. At a later period Whetstone transformed it into a prose story in his "Heptameron of Civil Discourses" (1582), and Shakspeare used it to a better purpose than he in his "Measure for Measure." "The Rock of Regard," which Whetstone styles "the first increase of his barren braine," appeared 1576. It is a collection of tales and poetry, original, selected, and translated, divided into four parts:—"The Castle of Delight," "The Garden of Unthriftinesse," "The Arbour of Vertue," and "The Orchard of Repentance." From one of these stories, "The Lady of Boheme," Massinger drew the plot of "The Picture." His "Remembrance of George Gascoigne" (1577) is a brief valuable sketch of the life, services, and works of that poet, and supplies us with the titles of some printed works of the author of "The Steele Glasse"—such as "The Glasse of Government," "Diet for Drunkards," "Hunting," and notices of some unpublished productions. His "Mirror for the Magistrates of Cities" bears on its title, George Whetstone, Gent., *malgre de Fortune* (in spite of Fortune). To encourage men to offer their services in the struggle between the Netherlands and Spain, Whetstone issued "The Honourable Reputation of a Soldier" (1585), which he afterwards included in his historical miscellany, "The English Mirror" (1586).

Among other early dramas presented to Queen Elizabeth we know of "Iphigeneia"—which may have been John Lumley's version of the Euripidean tragedy—given on "Innocents daie at Night [28th December], 1571, by the Children of Powlis;" "Ajax and Ulysses" on "Newe yeares daie," by the children of Windsor (1571–72); "Narcissus," "by the Children of the Chappell;" "Paris and Vienna," by the children of Westminster; "Lady Barbara" and "Cloridon and Radiamanta," by Sir Robert Lewis' men (1571). A large number of other plays performed at court (1568–80) are known by name; but no remains of them survive. A considerable number have been collected into editions of "Old Plays," edited by Thomas Hawkins (1773), Robert Dodsley (1774)—re-issued by Isaac Reed (1780), J. P. Collier (1825), W. C. Hazlitt (1872–76)—C. W. Dilke (1814), J. P. Collier (1833), and Sir Walter Scott (1810–11), &c. Several have been issued in the publications of the Roxburghe, Percy, Shakspeare, and other societies, as well as by literary gentlemen—*e.g.* Thomas Sharpe, W. Marriott, J. O. Halliwell-Phillips, Dr. Grosart, A. H. Bullen, Churton Collins, &c. In 1860 J. O. Halliwell-Phillips issued his "Dictionary of Old Plays" in print and MS.; and Mr. F. G. Fleay has most industriously catalogued, in chronological and other tabular forms, a great number of old plays, culling the ascertainable facts regarding them from every available literary repository, and arranging them in his "Shakspeare Manual," &c. Even from these industrious gleaners' collections we can form but a slight conception of the amount of intellectual activity which found an outlet in representative literature, or as Bacon defines dramatic poetry, "history made visible." Men of the most prolific powers of inventiveness, under the stimulus of clamant demand and immediate appreciation, wrote innumerable dramas, and young men who had been successful in winning applause in school and at college in acting plays, attracted by the immediate applause and pay which theatrical performances brought—patronized as they were by the sovereign and her court, by the nobles and their clients, the citizens and the populace—took to the stage as a profession.

Among the "scholar-poets" who furnished the stage with its most charming novelties there are enrolled many illustrious names—Lyly, Greene, Peele, Lodge, Nash, Kyd, and Marlowe. To them the drama was presented as a tradition; they passed it on to their successors as a trade. All these—except Lodge, who took to seafaring and to medicine—brightened by their genius the enjoyments of the people during the last quarter of the sixteenth century.

John Lyly, born in the Weald of Kent, 1553, in 1569 entered Magdalen College, Oxford, became M.A. four years thereafter, and leaving the university (on some untold cause) proceeded to London to subsist on the precarious capital of his wits. When in his twenty-seventh year (1579), he issued "Euphues, the Anatomy of Wit." It had immediate and astounding success: two editions were exhausted within the year. In the spring of the next year a second part was published, "Euphues and his England." This fashionable book was twelve times republished within fifty-seven years. So much did it fascinate society that, according to Edward Blount, "it taught our nation a new English," affected manners, and suffused literature. It is greatly made up of false science, idle rhetoric, tawdry phrases, and undisciplined phantasies, and yet it is taking, amusing, and didactic—a kind of essay-novel, with a thin tissue of story and a large amount of well-said but utterly fabulous things: while

> "Talking of stones, stars, plants, fishes, and flies,
> Playing with words and idle similies."

Lyly entered the service of Lord Burleigh, was candidate for the position of Master of the Revels, and an onhanger at the court. He was a craftsman in composition, and interwove antique classic lore with modern allegory in the fine-tissued tapestry of his courtly and courtier comedies. The first of these, "The Woman in the Moon," is in blank verse, and is founded on the fable of the creation of Pandora; but many good critics—Collier, Ward Symonds, &c.—doubt if this is really a production of Lyly's, though it was published with his name during his lifetime, in 1597. The second is "Alexander and Campaspe," probably suggested by a ballad entitled "An History of Alexander, Campaspe, and Apelles," founded on an incident in Pliny's "Natural History" (xxxv. 10), printed for Colwell in 1565, and played before Queen Elizabeth on Twelfth Night, 1584, by the children of Paul's. "It is full," as William Hazlitt says, "of sweetness and point, of Attic salt and the honey of Hymettus." In it he flattered the royal maiden by showing how power can resign love, and gain glory by doing so. "Endymion and the Man in the Moon" (1591), the plot of which is taken from Lucian's "Dialogue between Venus and the Moon," veils in its brilliant moonshine the haughty virginity of the Cynthia of England. "The theme of purity in a divine or royal maiden is one of the most delicate that art can touch," and (as J. A. Symonds says), "Lyly has treated it with quaint and courtly grace." It is "a censer of exquisitely chased silver, full of incense to be tossed before Elizabeth upon her throne, with Leicester and her ladies at her side." "Sappho and Phaon," founded on the first of Ovid's epistles, is so told as to encourage in the court the idea of ardent love purified into passionate "loyalty, unspotted though unrewarded." "Galathea" is a transference of the fable of "Iphis and Ianthe," in Ovid's "Metamorphoses IX.," from Phæstus in Crete to Lincolnshire, as an underplot wherein two girls disguised as boys fall in love with each other and make very pretty sport, while the more classical elements in which the gods engage are complicated round the yearly sacrifice of a virgin to the sea-monster Agar—the Æger of Scandinavian mythology, the god of the ocean, whose daugh-

ters are the billows. It is intended to suggest that there is a love higher than that which is sexual. "Midas," though owing its plot to "The Golden Ass of Apuleius," which had been translated by Adlington in 1556, is pretty clearly an ingenious political allegory in which Midas represents Philip. Lesbos, which the gods have pitched out of the world, as not to be controlled by any in the world, signifies England, of which, of course, Elizabeth was the Diana. Hear how Philip, in the guise of Midas, speaks of his aggressive policy and of his West Indian gold:—"I have written my laws in blood, and made my gods of gold. Have I not made the sea to groan under the number of my ships? and have they not perished, that there was not two left to make a number? Have I not enticed the subjects of my neighbour princes to destroy their natural kings? To what kingdom have I not pretended claim? A bridge of gold did I mean to make in that island where all my navy could not make a breach. . . . Is not the country walled with huge waves?" "Mother Bombie," a cunning old woman of Rochester, requires to unravel a compound "comedy of errors" arising from interchanged children, and does so after some farcical conceits in such a manner as to put no impediment in the way of true love. "The Maid's Metamorphoses," "Love's Metamorphoses," and "A Warning to Faire Ladies" have also been attributed to Lyly; and perhaps "The Woman in the Moon," though published in 1597 as his first play, may have been really a late satirical performance intended to revenge himself on a sovereign whom he had over-flattered, but to whom in 1593 he wrote (unavailingly):—"My last will is shorter than mine invention; but three legacies—patience to my creditors, melancholy without measure to my friends, and beggary without shame to my family." He died November, 1606, aged fifty-two.

Robert Greene was born in Norwich, of "parents who for their gravitie and honest life were well-knowne and esteemed among their neighbors," about 1560. He was in his "nonage brought up at schoole," and entered St. John's, Cambridge, 15th November, 1575. He took B.A. in 1578, and M.A. in 1583. Between these periods he wandered with some wild college friends in Spain and Italy, greatly to the detriment of his morals. He was shapely in body when dressed, looked a scholar-like gentleman, only his hair was somewhat long; he wore his beard in a peak, his features were amiable, ruddy, and his hair light auburn. He was pretty costly to his parents, but at length found his way to London, and became an author of plays and a penner of love-pamphlets. Ill-fitted by temperament and without any professional position, though it is really not improbable that he was admitted vicar of Tollesbury, in Essex, 19th June, 1584, and after an incumbency of a year and a half, of his own free-will and without fault leading thereto, resigned the same, 17th February, 1585-86, in which year, having fallen in love with a beautiful girl named Dorothy, "a gentleman's daughter of good account" in Lincolnshire, he married. In the following year they parted, and he emerged again into London life, "and glad was that printer that might be so blest to pay him deare for the very dregs of his wit." Undermined alike in constitution, character, and faith, he gave himself up to the dissipations of city life; alternating between furious off-hand work and worrying remorse, he was for a time the king of good fellows among his boon companions. At length, in degradation and wretchedness, lodging in a poor shoemaker's house in Dowgate, racked with pain of body and mind, neglected by almost all his summer-seeming friends, forsaken even of the sister of the ill-famed Cutting Ball, with whose company he had replaced that of Dorothy of Lincoln, and indebted to his landlady for the mere necessities of his deathbed, he died 3rd September, 1592, from the effects of a greedily partaken supper, of which the attractive delicacies were pickled herrings and Rhenish wine. His landlady crowned the dead author's head with bays, and bore the cost of his interment in the new churchyard near Bedlam. A large number of prose pamphlets of almost every variety are attributed to him, and thirty-three of these have recently been edited by Dr. Grosart. Among them are (1) sad love stories like "Mamillia, a Mirror for the Ladies of England" (1583), which tells the story of the beautiful daughter of Gonzago, ruler of Padua, and the hero Pharicles; "Arbasto [King of Denmark], the Anatomy of Fortune," whose love for Doralicia, daughter of Pelorus king of France, wrought his ruin; "Pandosto, or the Triumph of Time" (sometimes also called "Dorastus and Fawnia"), founded on a legend regarding the Polish Duke Mazovius Zernovitus and his wife, from which Shakspeare drew the plot of "The Winter's Tale;" "Perimedes the [Memphian] Blacksmith, and his wife Delia," derived from the "Decameron" II. vi.; "Gwydonius, or the Card of Fancy," &c.; (2) pastoral romances like "Menaphon or Arcadia," a complicated and interesting though improbable story; "Morando, the *Tritameron* of Love," illustrating by anecdote, quotation, and story how to use love and eschew lust, &c.; (3) moral tales like "Penelope's Web," commending the virtue and graces of obedience, chastity, and silence; "Cicero's Amor;" "Tullie's Love," a story in favour of friendship and patriotism; "Alcida," called also "Greene's Metamorphosis," because he who in "Penelope's Web" had earned the title of "Honour of Women," in this becomes their detractor, and writes "to teach us ware of women's lookes," their frivolity and gossiping, &c.; (4) his exposures of coneycatchers; (5) his political pamphlet against Philip of Spain, 1588, "The Spanish Masquerado;" and (6) his autobiographical novels, a wonderful and touching series of repentant pamphlets: "Greene's Mourning Garment" and "Farewell to Folly," "Greene's Never too Late" [to mend], "Francescoe's Fortunes," "Groatsworth of Wit bought with a Million of Repentance," "The Repentance of Robert Greene," and "Greene's Vision." From these pathetic confessions of sin and sorrow, poured out in hot passion, Greene's character has perhaps been too harshly judged, and it is all the more sad that Greene's enemies, like Job's, said, "Thine own mouth condemneth thee; yea, thine own lips testify against thee." Of Greene's numerous early dramatic pieces there are no (known) survivals. These four, wholly written by him, are authentic:—"Friar Bacon and Friar Bungay,"—founded on a legend of the notable Franciscan monk entertwined with a romantic underplot of "Margaret of Freshingfield's love difficulties between Edward, Prince of Wales, and Lord Lincoln"—is blithe, varied, fresh, and unflaggingly humorous; "Orlando Furioso," derived from Ariosto's epic, is full of love, rivalry, jealousy, and madness, often expressed with singular power; "The Scottishe History of James IV., slaine at Flodden," though deceptive in title, for the plot is quite fictitious, is effective and well-constructed, and notable for giving the name of Greene's wife Dorothea to the fine feminine queen for forgiving James, who had "sought sinister loves and forraine joyes," and for the introduction to the stage of Oberon, king of the fairies; "The Comical History of Alphonsus, King of Arragon," is rather a stirring series of pageants, battles, conquests, with a poetic commentary, than a play. In addition to these he wrote, along with Thomas Lodge, "A Looking-Glasse for London and England," a dramatic apologue from the fate of Nineveh, in which the serious and the comic are curiously mixed. "George-a Greene, the Pinner of Wakefield," is attributed to Greene in a note on the title page of a copy in which Ed. Juby [a player, author of "Sampson," 1602] quotes William Shakspeare as his authority. "Selimus, Emperor of the Turks," is assigned to Greene in consequence of two passages from it which occur in "England's Parnassus" (1600), having his signature affixed to them, as well as from similarities of idea and freaks of phrasing.

George Peele, a Devonshire gentleman, born in 1558, educated at Christ's Hospital and at Christ's Church, Oxford, where he graduated B.A. 1577, was early famous as a craftsman in words. His English version of "Iphigeneia" was praised while a student by Dr. Wm. Gager, author of many excellent Latin plays—Dido, Meleager, Rivales, Œdipus, Ulysses Redux, &c. Campbell says Peele's "David and Bathsabe" is "the earliest fountain of pathos and harmony that can be traced in our dramatic poetry." In his earliest and best work, the court-masque of "The Arraignment of Paris," he displays, as Nash says, "pregnant dexteritie of arte and manifold varietie of invention," and flatters Elizabeth with the smoothest of rhymes. "Sir Clyomon and Sir Clamydes" is written in common metre, and in it Neronis takes on the

guise of a page—a stage trick often afterwards employed. "The Famous Chronicle of Edward I." takes up a vulgar and malicious libel on Eleanor from an old doggerel ballad, and uses it to incense the people against the prospect of a Spanish match. "The Battle of Alcazar" is ranting and melodramatic. The chief interest of it arose from the introduction of a Devonshire hero, Tom Stukeley, who fought and died on that African field in company with three kings, 4th August, 1578. Pistol's "Thus feed and be fat, my fair Calipolis," is a compound of two lines in this play; and his punning question "Have we not Hiren [=Irene and iron], here?" refers to a lost drama noted below. "The Old Wife's Tale" is involved and intricate in plot, fresh and humorous in style, and full of poetic fancy. Several characters have names derived from Ariosto's "Orlando Furioso," and Milton makes excellent use of some of the ideas in it in his "Masque of Comus." "Turkish Mahomet and Hiren the Fair Greek," though spoken of as a famous play, is lost. Peele was engaged to arrange a pageant to grace the meeting of Elizabeth and Mary Queen of Scots; and two pageants, prepared for the lord mayor's days of Sir Wolstone Dixie (1585) and of William Webbe (1591), have reached us. In 1583 Peele was concerned in the production of two plays at Christ Church, when the university, at Her Majesty's desire, received Albertus Alaseo, the Polish prince palatine, hospitably. In the same year he married, and, through his wife, held an estate. He composed "The Tale of Troy," published 1587; "Polyhymnia," 1590; and "The Hunting of Cupid," a dramatic pastoral, 1591. It is supposed he died in 1598.

Thomas Lodge was the second son of a lord mayor of London, born 1558, and educated at Trinity College, Oxford, where he took his M.A. in 1577. He entered Lincoln's Inn in 1578, but did not settle to his studies. Having joined Clarke and Cavendish in their expedition, he visited the Canaries, and wrote his delightful romance of "Rosalynde"—on which Shakspeare founded his "As You Like It"—rocked on the waves of Magellan's Straits. Returning to Europe, he studied medicine at Avignon, and established himself as a physician in London. He is supposed to have died in 1625 of the plague, on which, in 1603, he had composed a medical treatise. While yet in Lincoln's Inn, about 1580, Lodge wrote, in answer to Stephen Gosson's "Schoole of Abuse," "A Defence of Stage-plays," to which, though it was suppressed by authority, Gosson immediately replied in "Plays Confuted in Five Acts." In 1584 appeared an "Alarum against Usurers," containing also "The Delectable History of Forbonius and Prisceria" and the "Complaint of Truth against England." To him also we owe translations of the works of Josephus (1602) and of Seneca (1614). "The Wounds of Civil War" between Marius and Sulla (1594) is a historical play, founded on Sallust and Plutarch, in which the male characters are firmly outlined and the incidents stirringly set forth, but the blank verse is stiff rather than stately. This drama was preceded by a kind of historical romance on Robert, second Duke of Normandy (surnamed "for his youthful imperfections" Robert the Devil); by "Catharas;" "Diogenes in his singularitie, christened by him a Nettle for true Noses," a satirical prose tract on the vices of all ranks and conditions of peoples; and by "The Life and Death of William Longbeard," abridged from the early chronicle histories (1196), in which he mixes fact with fiction and prose with verse. In a collection of satires, eclogues, and epistles, entitled "A Fig for Momus," he is rough and wrathful. Lodge's poetry did not merit the neglect it met with; he is often deliciously lyrical. From his pliant pen he gave "Scilla's Metamorphosis" (1589), the versification and matter of which seem closely akin to Shakspeare's "Venus and Adonis;" "Philis" (1593), which follows in style and form Daniel's "Delia;" perhaps "Prosopopeia" (1596); and "The Tears of Marie, the Mother of God." Nor have we even yet exhausted the catalogue of the products of his versatile genius. His "Sailor's Kalendar" has not been preserved. It seems to be uncertain whether "Euphues' Shadow" (1592) was really written by him and edited for him by Greene, or palmed off as his by Greene while Lodge, being at sea, could not contradict the ascription. Of "Wit's Miserie and the World's Madnesse" (1596) Lodge had certainly seen his own share, and had done his own part in "discovering the devils incarnate of this age" in the pamphlet which contained, along with this work, the pieces entitled "Marguerite of America" and the "Devil Conjured." Several commentators imagine that Shakspeare alludes to Lodge and his work in the line—

> "Some see more devils than vast hell can hold."
> —*Midsummer Night's Dream*, V. i. 9.

It is probable that Lodge is referred to as "pleasing Alcon" in Spencer's "Colin Clout's come Home again" (1591); and Lodge in his "Phillis" repays the compliment by speaking of "learned Colin as a pastoral poet

> "Who hath the palme for deepe invention wonne."

Michael Drayton, to whom Lodge addressed a poetical epistle, contained in "A Fig for Momus," refers to this, and at the close of his "Endymion and Phœbe" celebrates his friend under an anagram, as—

> "Than my Goldé, which in summer dayes
> Hast feasted us with merry roundelayes:
> And when my muse scarce able was to flye,
> Didst imp her wings with thy sweete poesie."

Lodge took Greene's dying advice to playwrights, and retired from dramatic writing soon after his fellow's melancholy end.

Of Thomas Kyd's personal history nothing is known, and of his works but little. Meres mentions him as among "the best tragic writers" of the time. In Ben Jonson's "Verses on Shakspeare" Kyd is ranked with Lyly and Marlowe as playwrights whom that dramatist outshone. In the dedication of his translation of Robert Garnier's play, "Cornelia," to the Countess of Sussex, he speaks of having "no leisure, but such as evermore is travailed with the afflictions of the mind," of her "honourable favours past" as his patroness, and of the "so bitter times and privy broken passions that I endured in writing it," while he announces his design of proceeding with the tragedy of "Portia." "Cornelia" was printed in quarto 1594, and again in 1595 as "Pompey the Great his Faire Cornelia's tragedie," and from the non-appearance of "Portia" or any other work from his pen after that date, we may suppose that Kyd's "next summer's bitter travel" was taken under the care of

> "The arbitrator of despairs,
> Just death, kind umpire of men's miseries."
> —*I. Henry VI.* ii. 5.

Kyd was the author of "The Spanish Tragedy, or Hieronimo is Mad Again" (1594), and he is therefore supposed to have produced "The First Part of Hieronimo, with the Warres of Portugall and the Life and Death of Don Andrea," to which Ben Jonson, who took the part of Hieronimo, refers in "Cynthia's Revels" (1600) as "the old Hieronimo," which, it had been thought, "as it was first acted" (1588?), was the "only best and judiciously penned play in Europe." The vigour, passion, and imagination it displays rendered it very popular, and it ran through many editions. From a similarity in some of the thoughts in it to several that occur in "Hamlet"—and it has both a ghost and a play within a play in it—Kyd has, without any other foundation, been credited with being the author of a play having that title (acted 9th June, 1594), which is supposed to have preceded Shakspeare's tragedy. To him has also been attributed the authorship of the old play of "The Taming of *a* Shrew," on which Shakspeare is supposed to have founded his lively and popular comedy of "The Taming of *the* Shrew." J. P. Collier says, if he might be "allowed a conjecture," he would also assign to Kyd the anonymous tragedy of "Solyman and Persida" (1599). That Kyd was imitated as well as ridiculed may be taken as good grounds for regarding him as a man of really original power and inventiveness, and that Ben Jonson speaks of him so frequently and so well tends to increase the strength of this impression.

Thomas Nashe was the third son of William Nashe, minister at Lowestoft, Suffolk, by his second wife Margaret. He was born in November, 1567, admitted October, 1582, a sizar of St. John's College, Cambridge, and on being placed

as a scholar on the Lady Margaret's Foundation, resided at the university six years and three-quarters, and "commenced author" in London, 1589, by prefixing a very noticeable address "To the gentlemen students of both universities" to Greene's "Menaphon." He set to work for the booksellers and theatres. For example, on the publication of Sir Philip Sidney's "Astrophel and Stella" (1591) he was employed to preface it with "Somewhat to Read for them that List." He next had a dash into the Martin-Marprelate controversy regarding the scripturality of Episcopacy, the lengthy history of which Edward Arber has investigated and discussed. Nashe took the prelatic side, and wrote "A Counter-cuffe to Martin Junior," "The Returne of the Renowned Cavaliere, Pasquill," "Martin's Month's Mind," and "The First Part of Pasquill's Apologie" (1589–90). In a piquant series of personal pamphlets he retaliated on Gabriel Harvey for some offhand abuse of his dead friend Greene, who had stated in a "Quip for an Upstart Courtier" that Harvey was the son of a ropemaker in Saffron Walden. This literary squabble excited all England then, and has since occupied a large space in critical writings. Here we merely mention it as a grief morally, though intellectually the occasion of much clever wicked wit:

> "His style was witty, though he had some gall;
> Something he might have mended, so may all."

In 1597 Nash produced for Philip Henslowe "The Isle of Dogs." It offended the Queen's Privy Council, and they withdrew the license from the lord-admiral's players and imprisoned the author. Among his other works were "Pierce Pennilesse; his Supplication to the Devil" (1592), a most pithy satire of, and invective against the later days of great Elizabeth; "The Unfortunate Traveller, or the Life of Jack Wilton;" "The Terrors of the Night" (1594), and "Dido, Queen of Carthage," a tragedy, played by the children of her majesty's chapel—apparently left "in the rough" by C. Marlowe, and finished by Nashe; "Summer's Last Will and Testament" was presented at Croydon, probably before Bishop Whitgift, with the queen present in private as an auditor, the *dramatis personæ* being undertaken by the pages of the household, under the author's direction—all doing homage

> "Unto Eliza, that most sacred dame,
> Whom none but saints and angels ought to name."

It is rather as a dramatic pageant and display of rare dexterity of wit and pen—in fact, as a poetical performance, and not as a play—that it should be read, studied, and judged. Nashe died, under circumstances unknown, in the thirty-third year of his age (about 1600), being survived by his father, who died in 1603.

HISTORY.—CHAPTER IX.

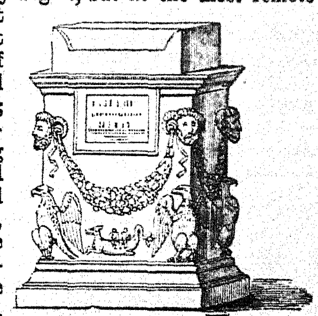
GREECE AND INTELLECTUAL CULTURE—ROME AND ITS GOVERNMENT—THE EARLY AGES OF CHRISTIANITY—THE ROMAN EMPIRE FROM AUGUSTUS TO CONSTANTINE THE GREAT.

SOCIETY, as a corporate organization, requires the recognition of law, religion, and education. Law is protective of life and property, and hence is (1) *distributive*, declaring the rights and duties of individuals; (2) *punitive*, assessing and enforcing penalties for the transgression of distributive law; and (3) *executive*, wielding the associated power of the state for the maintenance of order, safety, peace, and right. The state as a legislative power appeared in its fulness in Imperial Rome, the lawgiver of the world. Religion concerns itself with the culture of the inner life in its emotions and desires, in their relations to "men in nations," human beings as individuals, and with the soul in relation to God and eternity; it seeks thereby to preserve and increase the purity and piety of the personal life, and to maintain a full consciousness of the worth and dignity of man's spiritual nature. Religion manifested itself in its most varied, powerful, and loftiest forms in the Eastern nations—Persia, India, Egypt, and Palestine—in the latter of which it became embodied as law and ritual, and symbolized in the temple worship made imperative on the nation. Education endeavours to develop in man, both individually and collectively, the knowing, reflecting, and constructive faculties of the mind (1) by calling attention to nature and science; (2) by communicating information regarding the observations, discoveries, and productions of inquirers into the properties and capacities of things; and (3) by exhibiting the means employed by others in their investigations, and so indicating and suggesting the means of reaching other, higher, and more useful results. Education as the awakener of thought appeared in its most active condition in Greece, the birthland of culture as an end in human life, as a real and valuable development of the personal powers of man. Thus religion came to be more and more exclusively developed among the nations of Asia Minor, Syria, and Egypt, philosophy among the people of Greek extraction, and legislative skill and science among those of Roman progeny. Of Greece mainly as the community in which thoughtfulness was most consciously cultured, we must now take account.

The earliest source of information respecting Greece is the history of Herodotus, read to the Greeks at the Olympic games, about B.C. 447. From that period onward we have an almost unbroken line of contemporary authors. Thucydides gives us a continuation of Herodotus, and Xenophon of Thucydides. The Attic orators and philosophers fill up the space that intervenes between the records of the latter and the age of Alexander. Fragments of journals and of more systematic historians contemporary with Alexander have been preserved. Polybius, the writers of the Alexandrian school, Strabo, and Plutarch of Chæronea come next. These writers are complemented and illustrated by a contemporary literature of unsurpassed originality, beauty, and variety. Greece is rich, too, in that class of monuments which, having inscriptions on them, are valuable and trustworthy sources of history. Its specimens of architectural and sepulchral art are as unequalled in number as they are in beauty.

The first period of the history of independent Greece—independent in the sense of freedom from foreign influence—extends from the earliest times of which we have any record to the commencement of the reign of Alexander, in B.C. 337. Only during the last 106 years of this period are we possessed of contemporary historians. This disadvantage the independent Greeks shared with the Roman republicans. The records of the circumstances under which the peculiarities of Greece developed themselves and acquired form are in all probability irrecoverably lost. What can be guessed rather than inferred from these sources may be briefly stated thus:—

The original seat of the Greek tribes appears to have comprehended all the mainland of that portion of Europe lying between the Gulf of Adria and the Ægean Sea, north of a line drawn from Mount Olympus, on the latter, to a little north of Corfu, on the former, constituting the Peloponnesus, or, as it is now termed, the Morea. This, with Crete and the islands of the Archipelago, constituted Greece, not only when contemporary history begins, but at the most remote period to which we can waft a conjecture. The earliest metaphysical legends of Greece mirror the physical features of this country; traces of elementary convulsions of which strong indications may still be read in the superficial forms and internal strata of island, cape, and mainland. The flood of Deucalion, the fabulous Typhon, and the equally fabulous Chimera, and the thunder-god—the supreme national deity of the Greeks, &c.—bear unequivocal marks of being native to the soil, or, like the Venus of its mythology, sprung from the sea which laves its shores. Besides the indigenous gods of Greece, divinities had been imported from Egypt and Phœnicia. The Athene of Athens and the Venus of Paphos had been ingrafted, by fic ons of paternity, upon the stock



Grecian Altar.

of the original gods. In Oceanus and Saturn we have indications of the memory of older gods, whose worship had been banished to make way for the new denizens of Olympus. But there is a still more striking feature in the theogony of Homer. In Anagke (necessity), who controls gods as well as men—the vague but grand allegory of a golden chain binding together heaven and earth, men and gods, their fates and their actions—we recognize the struggles of mind to free itself from a polytheism which had been forged by imagination, and had lost in intensity of feeling as it gained in precision of form. The philosophic spirit rapidly reached its full growth (in Socrates, Plato, and Aristotle), and the fair mythology of ancient Greece could "live no longer in the faith of reason."

The Greek tribes sprang from the Pelasgi and the Hellenes. Herodotus confesses his ignorance whether these two races spoke the same or a different dialect. He regards Ionic as Pelasgic and Doric as Hellenic. He places the Hellenes in a district extending from the Straits of Thermopylæ to the borders of Macedon. From this they first shifted gradually northward, then turned southward, and finally occupied the Peloponnesus. The Pelasgi were, he tells us, a stationary race, and he informs us that the inhabitants of Attica and Ionia were of this race—a fact partly corroborated by a passage in the second book of the Iliad, which contains an accurate and authoritative description of the distribution of the Greeks. The names given are various, but there are three which designate the whole host—Hellenes, Achaii, and Danai. Everything seems to show that the Greeks were mainly an unmixed people, splitting into more and more numerous clans as they increased in number, the Pelasgi and the Hellenes being the oldest.

The manner in which the Greek clans diffused themselves can be clearly traced, and the plan continued for at least the first hundred years of the period during which we possess a contemporary history. The records of the foundations of many of their cities have been preserved. The Greeks, like the Latins and other Italian tribes, inhabited hill forts, and cultivated the land in the immediate vicinity. They could not extend their limits when their population became redundant. They were obliged to send out colonies. Sometimes two, three, or even more neighbouring cities combined their forces. These swarms, though sent off from several cities, founded only one new city, and was called a colony of that which contributed the greatest number of inhabitants and furnished the institution with a leader. The colonists from each state were registered in one tribe, and this is the origin of the tribes which play such an important part in the constitution of many Greek cities, *e.g.* that of Athens. The relations of colonies to the parent state were various. Sometimes they were expelled in some revolution, and then there was no relation preserved whatever—only a family resemblance in laws, institutions, and religion. Sometimes an acknowledgment of relationship was kept up only through the instrumentality of certain religious rites. When the colony was weak and surrounded by powerful inimical neighbours, protection was afforded on a present being sent, or on the direct payment of a tribute. When the tribes within a colony were nearly equal old associations would prompt each to cling to its own state, and sometimes the internal quarrels of a colony would occasion wars and feuds between the parent states. Sometimes, too, wars between the parent states would produce commotions in a colony. The relationship between cities thus connected was more that of reliance than incorporation—more a matter of international than of municipal law. Each legislated for itself, and it was only with a view to mutual defence against external enemies that they were combined.

In this manner the Greeks extended themselves all round the shores of the Hellespont, to the Propontis and the Bosphorus; thus they became occupants of Sicily and the southern extremity of Italy, of Cyrene in Syria, and of the Delta of the Nile. In all these regions Greek cities, filled with a restless, enterprising, ingenious race, sprang up and flourished. Self-governed within itself, each city was continually altering its constitution as feeling or circumstance suggested. Such a state of affairs, though far from tranquil or comfortable, was by no means unfavourable to the development of the intellectual powers. The first rude notions of civil polity and morality became more comprehensive, refined, and definite, in such a school of experimental government. A century prior to the date of the oldest contemporary history, the Greeks were sufficiently advanced to admit of Lycurgus projecting and establishing a highly artificial model of a state. The Lacedemonian institutions were doubtless tinged with barbarism, yet they kept themselves for 500 years the most powerful among the Grecian states. Lycurgus hit the exact time when his townsmen were capable of being modelled into his ideal of good citizens. But in busy stirring times a few years of the education of events placed the rest of Greece on too high a scale of civilization to be made Lacedemonians of. Draco tried it, but his failure was signal. Solon, about the middle of the sixth century B.C. was more awake to what the times required. He gave not the best laws that could be made, but the best that could be carried into operation.

It was to be expected that amid a chaos of almost coordinate states some important and pervading changes should take place in the relations of the Greek cities, that some should outrun the others, and gain an ascendency over them. Lacedemon, in virtue of its institutions; Athens, Corinth, and Rhodes, in virtue of the activity and consequent civilization awakened among their citizens by favourable circumstances, were among this number. The war between the Persians and the Greeks modified and concentrated the natural tendency of power to be gathered into a few hands. The Greek race opposed a resistance to the Persian lust of dominion which it experienced in no other case except that of Jerusalem. The Greek cities, however, did not stand, like Jerusalem, alone—they were aided in their struggles by kindred and allied cities. When they heard of the Persian myriads, Athens and Lacedemon stood erect and undaunted. The latter sent her sons to lie in the gap at Thermopylæ that Greece might have time to rally. The former burned their houses and betook themselves to a home on the unstable bosom of the deep. A few of the Greek races only rallied round these heroic states, but they were hosts in themselves. Salamis and Marathon taught the Persian despot that Greece, animated by such spirits, was unassailable by physical force. This was an era in the history of man. Valour and skill in battle had been shown before, but this is the first recorded instance of the power that swells the freeman's heart and nerves his arm when he strikes against the rapacious hirelings of tyrannic power.

Coin of Corinth.

From the taking of Sestos by the Greeks, which terminated the Persian War (B.C. 478), to the battle of Chæronea, which made Philip master of Greece (338 B.C.), 140 years elapsed. Nearly a third of that time was occupied with a protracted struggle for ascendency between Athens and Lacedemon. The state of utter prostration to which, by this long struggle, Greece was reduced, and the other wars which arose after it, enabled Philip and Alexander to subdue it to their will.

Athens, single-handed, maintained a struggle against discontented and inimical colonies and the combined might of Persia and Lacedemon. Pressed down by the enfeebling effects of a fearful pestilence, she fell once, but soon recovered. Even under the agony of this death-struggle the soul of Athens had energy enough to thunder in accents such as were never heard in any other clime. Demosthenes, a mind equal to the best of Athens's best age, spoke in the sublimity of despair, conscious that he stood alone. Athens

was an important city in Greece before Sparta was founded, and was, in all but name, an independent state at the time of the first crusade. It thus enjoyed a longer life than the mightiest dynasty earth has known, and is an instance of the almost indestructible vitality of wisdom, energy, and patriotism.

As the legislator grew less powerful the philosopher bebecame more prominent. Moral philosophy in its earliest form supplied a collection of weighty and important precepts, each expressed with epigrammatic terseness, and easily impressed upon the memory. Some notions of physical science were gained by the wise men of Greece, which include certain advances in geometric science, as well as the observation of the heavenly bodies and of the surface of the earth. These indications of science made their first appearance in Ionia. Their own traditions frankly admit that they derived the use of letters from the Phœnicians; their knowledge of the divisions of the day and the art of constructing dials, from the Chaldeans; their first rude notions of mathematics—perhaps only of land measuring—from the Egyptians. It is evident that they had some notions of architecture and of the mechanical arts.

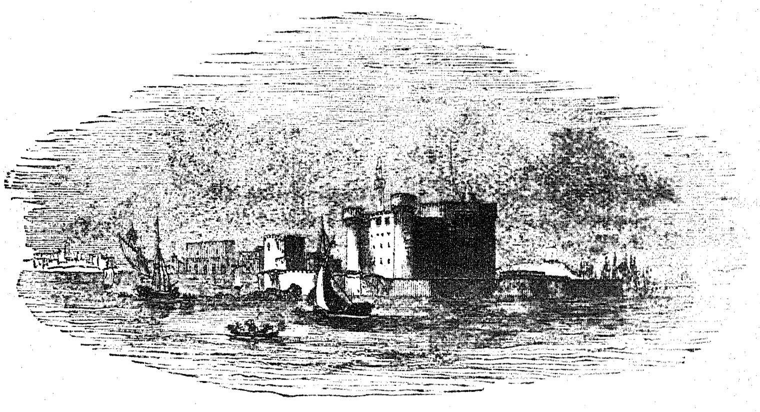
The exact sciences had so far advanced at a very early period that an Athenian astronomer introduced important reforms into the calendar. Plato pronounced mathematics the only sure preparation for the study of philosophy. Intellectual kept pace with physical science. Socrates was the first great teacher of a utilitarian system of morals. The useful and the beautiful were the two parallel lines which, according to him, hemmed in the straight path along which good men ought to walk. A man among men, he good-humouredly strewed on every side his recipes for making men good and happy. The more poetical soul and bold speculative genius of Plato sought to devise a system of morals and felicity improving to the race and to the individual. "Make men wise," said he, "and goodness will follow." The theories of Plato are mistaken; but his life was right, and so was that of most of his followers. Aristotle was a more abstract thinker. He loved knowledge for its own sake, and brought to the task of acquiring it a comprehensive intellect singularly skilful in classification and arrangement. This wonderful triumvirate may be regarded as having given that form to science which it retained in Christian and Mohammedan countries down to the fifteenth century.

Nor were they mere trainers of scholars and abstract thinkers; Xenophon, who, while yet a youth, led the shattered remains of the 10,000 from the heart of Persia through hostile nations back into Greece, learned his military ardour and art from Socrates. Dion, the liberator of Syracuse, was the pupil of Plato. Alexander, and several of his ablest leaders, were the scholars of Aristotle. These sages possessed the power of forming men who maintained characters in which the beautiful contended with the sublime for ascendency. The progress of composition kept pace with that of philosophy. The naïvete of Herodotus was followed by the terse weight and depth of Thucydides, and to both succeeded the amiable repose of Xenophon. So with poetry, which, under the peculiar circumstances of Athenian society, assumed the dramatic form. The dark and gigantic spirit of Æschylus witnessed, on the stage, his own dramatic version of the victory over the Persians, in which he had played a soldier's part; Sophocles touched a tender and deep tone of equable and sustained beauty; while Euripides clothed his wily sophisms in the language of real poetry. The arts of sculpture and architecture, neither of which, however, were indigenous in Greece, grew so glorious that it seemed as if, in the forms and statues of the age of Pericles, the buoyancy and elasticity of mind had been communicated to inert matter. Their form shows that they were importations from Egypt; and the earliest of these structures on record—the temple of Ægina—dates not long before the age of Pericles.

While mind was busy and productive in art, science, and literature it was not idle in public life. Ideal and dangerous notions of the end of government and of the means of attaining it were entertained by most of the Athenian statesmen.

The Romans, from Cicero to Quintilian, Pliny, and Tacitus, studied in the schools of Greece. In Alexandria the Hellenized Jews busied themselves in endeavouring to reconcile Plato with Moses, or to construct out of the Septuagint and the Platonic dialogues a concrete system of opinions differing from both. While the glowing Orientals and the callous Romans thus sat as docile pupils of the Greek sophists, and while Orientals and Greeks drank deep of the legal lore of Rome, such Grecians and Romans as felt the ardour and intensity of their religious yearnings unsatisfied with the shallow superficial creeds of their own races, received, with eager haste and tremulous awe, the mystic doctrines of Eastern Africa and Southern Asia.

From the foundation of the Empire to the close of the third century of our era Rome was the capital—the seat to which tribute flowed, the centre to which the busy and ambitious flocked. It was also the seat of a school of jurisprudence, and was frequented by the most eminent teachers of



Alexandria.

the sciences. Alexandria, the *entrepôt* of the commerce of the Mediterranean, the Red Sea, and the Upper Nile, was probably the wealthiest city in the empire. It was, besides, the seat of one of the chief schools of Greek science and literature, and the only haunt of Hellenized Jews. Byzantium was the centre of the commerce of the Euxine on the one hand and of the Propontis and the Hellespont on the other. Athens, a central point between Byzantium, Alexandria, and Rome, was not only of considerable commercial importance, but the principal seat of Greek science. Rhodes, intermediate between Attica and Alexandria; and Antioch, between the Mediterranean and Mesopotamia, were also notable for commerce and literature. Sicily, Carthage, and the southern extremity of Italy might be on an equality with the two last-mentioned empire cities. Schools of Hebrew literature flourished in Jerusalem and Babylon. Massilia, at the bottom of the Gulf of Genoa, brought the commerce of Great Britain and the regions beyond the Rhine into contact with Rome. Along all the routes connecting these depots, and in circles extending around each, commerce and intellectual activity were astir; and the inhabitants were proportionally civilized and refined.

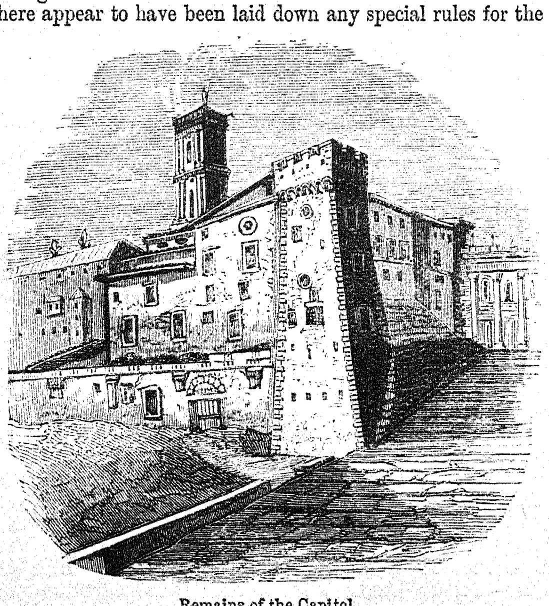
From the rebuilding of Jerusalem down to the time of Antiochus Epiphanes, Jerusalem was, as we have seen, a province with a governor of the Persian monarchy in the Greek kingdom of Syria. Under Antiochus the Maccabean family successfully asserted its independence. The Herodians wrested the temporal sceptre from the last prince of the Maccabees, and the authority of the magnates of Jerusalem and of the Jews was, from that time, spiritual. The Jewish race was from the time of Ezra to that of Christ a broken and a scattered people. But wherever they sojourned a certain uniformity of character and worship was kept up. They

THE ROMAN EMPIRE,
A.D. 117.

continued also to reverence the Pentateuch. Amid gradual decay and increasing disasters the colleges of the prophets of the Jewish state had begun to spiritualize the promises and doctrines of their faith. This propensity continued till the time of the Christian dispensation. The Pharisees affected a rigid observance of the law. The Sadducees were a more exclusive and philosophic class. The sect of the Essenes, by their spiritualizing of the ritual law, became the mental precursors of the teaching of Christ and his apostles.

The appearance of a Galilean teacher arrested public attention. "The people were astonished at his doctrines, for he taught them as one having authority, and not as the scribes." Jesus Christ declared man to be a denizen of eternity; he sought to raise his thoughts to the perfection of God by rendering God's excellencies the constant theme of man's meditations and sympathy, by constant struggles to check unholy emotions, and by exhortations to be holy, pure, and benevolent. By perseverance in these, he gave confident assurance that renewed efforts, after every lapse of human frailty, will re-purify and at last confirm in man the graces of virtue, the aspirations of hope, and the possession of celestial consolation. After his crucifixion, by those whom his virtues and his doctrines exposed and offended, Christ reappeared to his disciples, and renewed his injunction that they should teach all nations what he was—the Son of God—and inculcate those lessons of brotherly love which he had taught them while he dwelt on earth.

The Saviour's crucifixion took place during one of those high festivals which brought men of the Hebrew faith from every land to Jerusalem; and before the termination of these feasts many converts, who carried the seeds of his teaching in their hearts in every direction, were added to the church. Already, before the conversion of St. Paul, there were small societies of Christians to be found in many of the towns of Syria. The fervid spirit of Paul first burst these boundaries. In repeated excursions he traversed the whole of Asia Minor, Greece proper, from Athens to Corinth, Attica, and Crete, and finally reached Italy and Rome, in all making converts and planting churches. The other apostles and evangelists were similarly engaged in various parts of the East. The New Testament nowhere states that the apostles contemplated any immediate and direct change in civil society by their doctrine. Their object was simply to rescue men from the penalties of disobedience to the laws of God through the merits of their crucified Master. Nor does there appear to have been laid down any special rules for the government of the churches they established beyond those of good order and brotherly love.

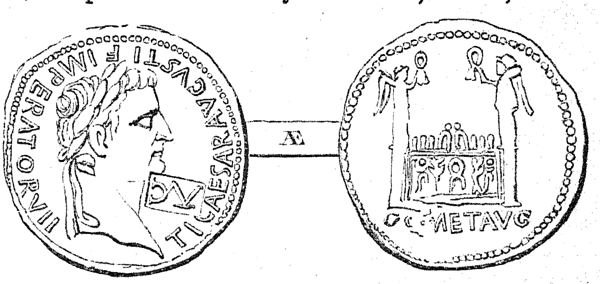


Remains of the Capitol.

The commencement of the Roman Empire may be dated from the year 708 of the city, *i.e.* about forty years B.C., on the appointment of Julius Cæsar to a dictatorship of, nominally, ten years, but which was intended to be a lease of power renewable till his death. The monarchy founded by Cæsar embraced the whole territory of the republic, and to this some additions were subsequently made. The unity of this immense empire continued till the year 450 of the present era, at which period it was divided into the Western and Eastern Empires—Rome being the capital of the one and Byzantium of the other. About 518 Rome was conquered by the Teutonic invaders; and the Eastern Empire, although straitened yearly into narrower limits, lasted until the overthrow of Constantinople, by the Turks, in 1543 A.D.

The general liberty of mankind was not in reality diminished one jot by the institution of monarchical government in Rome. Only the bare form of republicanism had survived the usurpation of Marius. To him had succeeded Sylla; to Sylla, Pompey; to Pompey, Cæsar, each with a sceptre as absolute as that of any of the emperors. The imperial sway served to limit the number of candidates for sovereignty in Rome, and thus diminished the chances of civil war. In the provinces the change was still less felt; and even when under the republic the provinces were not free. The boast of the Roman citizen was, that he was the equal, if not the superior of kings. When they deposed kings, it was not to give liberty to their subjects, but to reign over them in their stead. Under the republic Roman liberty was not for the provincials. The change for them was from the domination of an absolute oligarchy to the domination of an absolute monarchy.

The imperial power was not hereditary; it was granted for a period of five or ten years. It was, however, unlimit-

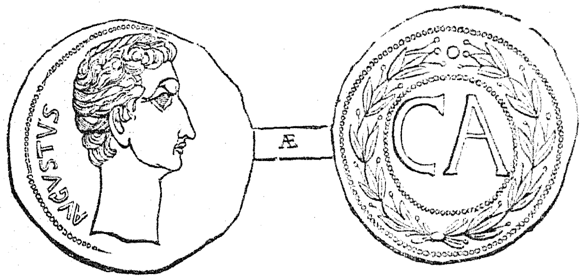


Coin of Tiberius.

ably renewable, and in the case of all the emperors the supreme power was only wrested from them with life. The right of election lay at first with the people; but so early as the appointment of Tiberius, the senate assumed the power of appointment. That body, down to the close of the empire, formally retained this privilege; but the army ultimately became the real masters of the state. Augustus organized a permanent camp of Prætorian Guards in the outskirts of the city. Another camp was added by his successors. The office of these troops was to enforce the police of the city, &c., and insure the safety of the emperor. They were the masters of the city; and the noble, wealthy, and ambitious were eager to be enrolled in a corps so highly privileged. Whoever could command the Prætorian Guards was chief in the state. Although the Romans had subjected themselves to the sovereign sway of one monarch, the idea of the transmission of the imperial power by hereditary succession never seems to have entered their minds. From the death of Julius Cæsar down to that of Alexander Severus—more than 250 years—there occur only three instances of the son succeeding his father. We find the sovereignty remaining, for limited periods, in the same family; but no rule of hereditary succession was observed. He who most skilfully ingratiated himself with the soldiery was sure to succeed. On the death of Tiberius the senate met to nominate his successor; but Caius Claudius had secured the army. An arrangement was entered into that the senate should go through the form of electing Claudius, no reference being made to his election by the army. This method continued to the close of the empire, although the business did not always terminate in the same brief and bloodless manner as on the first occasion. The emperor, when appointed, was

absolute. There was no check upon his will, except the dread and danger of displeasing those who gave him sovereignty and expected favour.

Under the sway of Augustus Cæsar the civilized world was Rome. From British Tyne to the Assyrian Tigris, from the sandy Sahara to the northern land through which the Rhine rolls, the Roman eagle marked out the land as regions under Roman power. It was no longer what Cicero had called it, "a fringe on the skirts of barbarism." Barbarism, with its hordes of homeless wild adventurers, lay beyond the circle of Augustus' sway, and cautiously evaded the touch of his sceptre, while it made those mighty migrations from among the ranges of Armenia, or the plains and steppes behind the stormy waters of the Caspian Sea, by which it peopled the north of Europe with elements of strife. In the fifty-eighth year of the age, and the twenty-sixth of the sole



Coin of Cæsar Augustus.

reign of this one man who ruled the world—in the first year of universal peace—a census was made, in which, in the city of Bethlehem, this name, according to Tertullian, was enrolled, "Maria ex qua nascitur Christus" (Mary from whom Christ is born). In this little thought of and less cared for Judean district of the Roman dominions, while Augustus was surrounded by military myriads, and about his throne were gathered wits, sages, and poets, this "child grew and waxed strong in spirit." He was ripening towards manhood when Augustus died (19th August, 767 A.U.C.) Then the imperial power passed into the hands of Tiberius. Into this self-indulgent and irresistible monarch—who rioted in revolting debauchery—humanity had matured; and it was while, from the island of Capreæ, one of the sunniest spots in the Mediterranean, under the "Judicia Majestatis," Tiberius gave forth his orders involving sorrow, suffering, despair, and death, that there was lifted up the voice of the carpenter's son, on a mount near the Sea of Galilee, saying to the people, "Come unto me all ye that labour and are heavy laden, and I will give you rest. Take my yoke upon you and learn of me, for I am meek and lowly of heart, and ye shall find rest for your souls." Though a few disciples adhered to this Great Teacher, and many heard him gladly, he was betrayed by a disciple, "despised and rejected" by his nation. On a false charge of treason he was delivered up by the civil and ecclesiastical authorities of Jerusalem to Roman jealousy, and by sentence of the Roman governor, Pontius Pilate, was crucified and slain. In the fifteenth year of the reign of Tiberius, Jesus Christ was crucified on Calvary "to redeem them that were under the law, that we might receive the adoption of sons," "for as many as are led by the Spirit of God, they are the sons of God."

Though, "through the tender mercy of God," "the Day-spring from on high" visited the people "to give light to them that sit in darkness and in the shadow of death, to guide our feet in the way of peace," wickedness remained in power. Caligula succeeded Tiberius, and Claudius to Caligula; each, more brutal and detestable than the other, found joy in exciting the terror and destroying the happiness of mankind. Rome was represented by Messalina and Agrippina, while the new empire was symbolized by Mary Magdalene and Dorcas; "for after that, in the wisdom of God, the world by [its] wisdom knew not God, it pleased God by the foolishness of preaching to save them that believe." The apostles, after "the day of his showing unto Israel," under the inspiration of the Divine Spirit, went forth as missionaries of the Cross into all the world, teaching and baptizing on their way. This little leaven of heavenly light and consolation helped greatly to leaven the whole lump of civil society, and the Church of Christ gathered together the company of the faithful. In Greece, Syria, Asia Minor, and at Rome also, Christ was presented as "a light to lighten the Gentiles."

While Imperial Rome demanded that its subjects should bow down to and obey the behests of the most depraved of despots, the apostles, taught by and as "ambassadors for Christ," proclaimed the equality of all men, because God was the father of all, and, pointing to the spectacle of death enacted on Calvary, besought them through faith in that sufferer, by patient continuance in well-doing, to "seek for glory, honour, and immortality—eternal life." While the good news of the gospel spread among the Gentiles, the Israelites, "of whom, as concerning the flesh, Christ came," continued in great measure doubting, resisting, and deaf to the message "that God was in Christ reconciling the world unto himself." Before the generation which had heard him speak, aided in reviling him, and saw him lifted up upon the cross, had passed away, the end of a long series of prophecy and threatening came, in one of the most terrible events in the records of time—the siege, capture, and destruction of Jerusalem (70 A.D.) Pestilence, famine, fanaticism, murder, suicide, slaughter, brought people, city, and temple to ruin. The sieger and the besieged in countless multitudes were "in one red burial blent." The Jewish dispensation ceased. It may not have been owing to their action in this unexampled and appalling assertion of Roman power over Jewish stiff-neckedness, but yet it is a remarkable fact that of the first twelve Cæsars only these two—Vespasian and his son Titus—who had borne command in Syria while the prophecies of the olden time were being fulfilled, are known to have died a natural death.

The Roman law always looked with suspicion upon corporations, threw impediments in the way of their progress, and disrelished their acquisition of property. These Christian corporations paid no respect to the popular worship. It is not surprising, therefore, that repeated persecutions of the early Christians should have taken place. It was the year of our Lord 211 before Christian societies, even in Rome itself, obtained the privilege of erecting and consecrating edifices for religious worship, the right to purchase and hold lands for the benefit of the Christian community, and to conduct the election of their ministers in a public manner. The Christians were by that time numerous; and the visible body continued growing in worldly power and estimation.

Almost immediately after the fall of Jerusalem, Christianity—which Nero scoffingly pursued with persecution, giving its old men to gladiatorial assassination, its maidens to the brutalities of the amphitheatre, and carrying on the sports of the night by flambeaux consisting of Christians coated over with pitch and set ablaze to light the streets of Rome—made such special progress as to awaken anew the hatred of the hirelings of despotism; and Domitian, somewhat faint-heartedly it is true, renewed the suppressive tactics of Nero. Nerva, after a soft and forceless reign of sixteen months, was succeeded by Rome's most active and vigilant soldier, Trajan, a Spaniard of imperial impetuosity and rare administrativeness. His discipline was drastic. He named Adrian, also a Spaniard, his successor. He to a universal genius united strong will and an exacting temper. Once the fierce blaze of his passions flared menacingly. Judea had risen in revolt. Barcho-Chebas led 3000 Jews into the field. Adrian exhausted three years' efforts to quell this rising. He sacked and burned a thousand villages and fifty towns; took Jerusalem, blotted out its name, and over the gateway of Ælia Capitolina (as he called the new city he commenced on its site) put up a statue of the abominable beast—a sow. Yet he is said, having found persecution of no force against those who gloried "in the cross of Christ," to have intended to have built and dedicated a temple to Jesus Christ, and it is singular enough that some verses beginning "Aimuula vagula blandula," composed by this drunken despot when anxious but unable to die, should in

the [improved] version of Pope have found their way into the hymnology of Christianity under the form of "Vital spark of heavenly flame."

Antoninus Pius (138 A.D.), good, wise, respected, and feared, held sway beneficently, and handed the sceptre, as he passed away (161 A.D.), to Marcus Aurelius, Platonist and Stoic, who persecuted the Christians as an unsocial sect, with eyes only on the outlook for, and hearts only eager to attain, an impossible perfection of character. Yet he had learned clemency and self-command. On his death-bed he gave reply to one who asked the watchword, "Go to the rising sun, I am just setting." But on the accession of Commodus the sun rose in darkness and blood. In his time the worship of Rome was flagrantly what it had long secretly been, an organized hypocrisy; and barbarism was no longer contented to look on at the wealth of Rome, but resolved on sharing it. Had it not been that nobler spirits were being bred in Rome than the members of the senate, the farmers of the taxes, the functionaries of the state, the minions of the court, the military in the garrisons, or the multitudes in the streets, it would have stood hard with the empire when the charmed entrenchments of its power were broken through by the hardy and restless freebooters of the borders. In thirteen years Rome revolted at the reckless atrocities of Commodus, and assassination made way for Pertinax to a throne which he retained only three months. The soldiery now brought the imperial seat into the market-place, and conferred it on the highest bidders. Didius, who bought it, Niger the Syrian general, brave and skilful as a soldier, and Claudius Albinus, to whom the British soldiery voted the purple, speedily gave way to Septimius Severus, who devoted to death every man of dignity, birth, wealth, or popularity, and stamped out with inflexible ferocity every attempt at insurrection. He died at York, and Caracalla (211 A.D.), who had attempted the assassination of his father through lust of power, leaped, as has been said, "like a famished tiger," into the sovereign throne. He inaugurated his reign by butchering his brother Geta in his mother's arms. Macrinus, Caracalla's agent in the execution of his crimes, thought he might as well employ rapine and murder for himself, and put Caracalla beyond need of a sceptre. Macrinus was speedily released from his tenancy of the throne, and Heliogabalus, a boy of seventeen, who had been brought up as a priest of the Temple of the Sun at Emesa in Phœnicia, became a Cæsar. Extravagant, suspicious, and self-indulgent, he lived to be the scorn of the soldiery who bestowed the throne on him, and he, being slain by the troops, was superseded by his cousin and (perhaps) stepbrother Alexander—then sixteen (222 A.D.)

Alexander had for mother Julia Mammæa, the sister of Soemias, who was the mother of Heliogabalus. It was reported that he had been born in the temple of Alexander the Great (whose name he received) in Arca Cæsarea in Phœnicia. Though brought up in Rome under the care of his grandmother Julia Mæsa, he was kept away from the contamination of the court. His mother acting as regent, selected a council of sixteen as her advisers and the guardians of her son, and placed the jurist Ulpian in command of the Prætorian Guard. Alexander Severus applied himself closely to the duties of his position, gave some time to literary culture, and was strictly, though not ascetically, moral in private life. He was gentle of spirit and ill able to regulate a soldiery so turbulent and corrupt as those with which he had to deal. He frequently referred, as his rule in life, to the words "Do unto others as ye would that they should do unto you." Maximin, a rough gigantic Thracian, murdered his benefactor and patron, seated himself in the prime place among potentates, and treated the empire as a conquered territory. The senate first chose the Gordians, but they were slain, then Maximus and Balbinus. The great Goth and his son, marching against them, were murdered in a mutiny before Aquileia. Then the Prætorian Guard assaulted the palace, slew the emperors, and Gordian III. became sole sovereign. He, finding the barbarians pressing him on every side, resisted their aggressions, but after a three years' reign was murdered in the East. Army and senate alike accepted Philip, an Arabian, as master. Numberless rivals arose, Valerian was captured by Sapor, king of Persia. Twenty imperial despots clutched the sceptre, and made war on one another. Probus (278 A.D.) for a while, by his warlike prowess, kept Rome's foes in check. Yet, though "his life and actions accorded with his name," a treacherous sword-cut emptied the throne. After a few almost spectral wearers of the purple, Diocletian acquired the sceptre, and turned his heavy hand against the Christians. Then he divided his dominion with Maximian, and when they both retired Galerius and Constantius shared the supreme power. Maximian stood for a while in the place of embodied power, and shortly afterwards Constantine carried the crown from Rome to Constantinople, and established Christianity as the religion of the empire.

This brought to a termination the terrible persecution of Diocletian. On his accession Constantine—the first Christian emperor, as he has been called—continued to venerate other deities than the Christian. Nor does he seem to have done more than restore to the Christians the power they formerly possessed of holding lands, and to have contributed liberally to many of the churches. He obtained the empire by standing forward as the patron of Christians, and he advanced them, in all civil privileges, to an equality with the pagans. Then the scale turned, and Christianity, checked only by the brief opposition of Julian, soon gained the ascendency. From that time a higher and purer tone took possession of society at large, and far inferior though it may be to what the gospel should do in making men brave, honest, sincere, and humble, that gospel is still there for him who will dare to look at it with his own eyes, and not through the opinions of fallible men. In the history of the middle ages and of modern Europe we shall be made aware of the essential changes which have been produced in the temper and morals of society by the influences of the Christian Revelation.

GEOGRAPHY.—CHAPTER IX.

AFRICA—POSITION—NAME—EARLY CONDITION—EXPLORATION—CONFIGURATION—HILL AND TABLE LANDS—LAKES—RIVER SYSTEMS.

AFRICA, the second in size of the greater continental divisions of the globe, is nearly three times as large as Europe. Its almost insular position separates it from ready contact with the other continents of the Old World; whilst the division of its whole mass by the equator into two similar climatic regions, lying nearly under the same parallels of latitude, the one north and the other south, occasions a greater sameness in temperature, conditions, and phenomena, and in the products of the animal and vegetable kingdoms, in its corresponding districts than is to be found in the two other old continents. It has its place in the Eastern Hemisphere. Lying to the south of Europe, from which it is separated by the Mediterranean Sea and the south-west of Asia, with which it is only connected by the neck of land known as the Isthmus of Suez. The Red Sea, the Arabian Sea, and the Indian Ocean interpose their waters between Asia and Africa. It extends from latitude 37° 20′ north to 34° 50′ south, and stretches between longitude 17° 30′ west and 51° 30′ east. It is of a somewhat irregular triangular form, with its vertex towards the south and its base-line running along the Mediterranean in the north. The Atlantic Ocean washes it on the west, and its eastern coasts are watered, as has been already stated, by the Indian Ocean, the Arabian and the Red Seas. The Capes Bon and Blanco in Tunis are the two promontories which project furthest north; and those of Good Hope and Agulhas (*ā-gool-yās*) form the most southerly extremities. Cape Verd, in Senegambia, is the most westerly point, and almost exactly east, in Somaliland, 4600 miles distant, Cape Guardafui (*Gwar-dā-fwée*) juts out into the Arabian Sea. If in its area we include its islands, Africa may be said to possess a surface of about 11,936,000 square miles.

Africa (Arabic *Ifrikiah*, cave-country) was only known in its northern and eastern parts by the ancients. The northern coast-land, lying along the Mediterranean to the west of Egypt, was first named in the Odyssey Libya (Gr. *Libua*), and the south-west wind which blew from it was called *lips*

(probably from Gr. *leibō*), because it brought rain. Strabo, who acknowledges Cneius Piso as his informant regarding the maritime country of Africa under Roman rule, compares that northern district of Africa to a panther's skin, having here and there refreshing spots of cultivation, showing themselves out from the yellow desert which they diversified. Strabo had visited several countries, and was with Ælius Gallus in Egypt 24 A.D., and he, as well as Herodotus and Aristotle, speaks of the Ethiopians (Gr. *aithō*, I burn, and *ops*, the face) as Troglodytæ and Ichthyophagi—cave-dwellers and fish-eaters. *Ifri* signifies a cave; its plural is *Yefren*, and that is the name of the most westerly of the three groups of mountains—Yefren, Ghuria, and Tarhona, in the south of Tripoli—the *Syrtica regio* of the Romans, in which were situated the *three cities* of Arbrotonum, Oea, and Leptis Magna. Even to this day the indigenous Berber (Gr. *barbaros*, uncivilized) tribes of the mountainous regions of Barbary hold to their old habits of dwelling in caves, clay-huts, and tents, and so from Greek to Roman, and from Roman to Arab the distinctive idea of African life has been implied in the name by which this great continent is known.

Less is known of Africa than of any other portion of the earth. It has long been the land of mystery. Military aggression, commercial enterprise, the curiosity and daring of explorers, the zeal of missionaries, and the enthusiasm of philanthropy, have all been employed in opening it up to intercourse, inspection, utility, and civilized life. To its natural inaccessibility, arising from its peculiar configuration and position; its want of large inlets of the sea, breaking into and indenting its coasts with entrances, provided with roadsteads and harbours, to its solid recesses; its intertropical heat, and the general unhealthiness of the interior, so far as Europeans and Americans are concerned, there have been superadded the barbarous and sanguinary, treacherous and jealous character of its inhabitants; their tribal quarrels and wars, feuds and unsociability; their defective *morale* and their practice of the slave trade. Yet the narrow valley of the Nile, though hemmed in on either side by desolate mountains and encroaching deserts, comprising Egypt, Nubia, and Abyssinia, was, as we know, in the earlier periods of history, crowded full of lusty life and famous alike for its art, commerce, science, prosperity, enterprise, wisdom, and luxury. As early as 1000 B.C. the Ethiopian city of Meroe, on the island-holm, inclosed by the rivers Astăpus and Astăbŏras, in the highlands of Abyssinia, had, in copartnery with Thebes, planted the colony of Ammonium in the Libyan Desert, and there set up the oracle of Jupiter Ammon, and instituted a caravan trade with the surrounding nomadic tribes. There exist in Ethiopia, as well as in Nubia, many ruins of magnificent temples, which have been adorned with skilled sculpture and made interesting by inscriptions. In Egypt, according to Herodotus, in the time of Amasis, there were 20,000 cities. In Upper Egypt the insular Philæ was a place of pilgrimage to the grave of Osiris, and there are still the best preserved group of ruins, mainly of temples, in the Nile valley. In Syene Juvenal died an exile, and in the opposite town of Elephantine there were, until 1818, many remains of Persian and Roman fortifications. The "hundred-gated" Thebes, the most ancient residence of the Egyptian kings, with the ruins of its architecture strews the ground for 2 miles on each side of the Nile. In Central Egypt there was Memphis, 10 miles from the pyramids, and the catacombs around the city, founded by Menes, the unifier of Egypt and its earliest national king, show where many now demolished cities rose in grandeur. On the Delta, by permission of Amasis, the Greek merchants established themselves at Naucratis. Sais was long a royal residence. In Busīris the chief temple of Isis stood. To the west of the Delta there were Canōpus (now called Aboukir) and Alexandria, before which the Island Pharos, with its famous lighthouse, lay. To the east of the Delta was Heliopolis or On, with its splendid temple of the sun, and swampy Pelusium, the key to Egypt coming from Asia, which Sennacherib unsuccessfully besieged, and where Psammĕnītus and Nectanĕbus were defeated. In later times, upon the shores of the Arabian Sea, there rose Arsinoë or Crŏcŏdīlopŏlis; Myos Hormus (mussel-port); Bĕrĕnīce, the chief trading city for the merchandise of India and Arabia; and Heroöpolis, on Ptolemy's canal, between the Nile and the Red Sea. Then there was the magnificent Phœnician-founded city and the arrogant state of Carthage. The former stood on a peninsula 30 miles in circuit, embayed between the two northernmost promontories, in the middle of the north coast of Africa. "The altars of the Philæni" (Lat. *aræ Philænorum*) form the boundary between Cyrene and Carthage on the east, and the river Tusca separated Carthage from Numidia on the west. This maritime state had, as one of its earliest foreign possessions, Sardinia and part of Corsica, the Balearic Isles, and some detached settlements in Spain. Her naval and her military forces were alike large. Against Greece Carthage maintained three wars in Sicily, and it was only after three serious and keenly-contested wars with Rome, in which men perished by tens of thousands, that Carthage was destroyed. While that city stood it was protected by the citadel Byrsa and by a landward triple wall, 30 yards high and 10 wide. Scipio's patriotism was repaid by Rome with the title of *Africanus*. Utica, where Cato committed suicide, was older even than Carthage, and there were, besides Adrumētum, Leptis the Less, and Thapsus, where Julius Cæsar overcame Juba. More westerly, beyond the river Malwa, and stretching to the Atlantic, was Mauritania, the scene of the Jugurthine war. The north of Africa seems to have been better known to the Romans than it is, even now, to us, though they knew little of the interior mass beyond—we should suppose, at furthest, the Niger—and were entirely unacquainted with the vast extent of its southern expanse. As a province of Rome it was full of flourishing towns, and being extremely fertile it furnished the great Italian state with its chief supply of corn-stuffs. It is a singular phenomenon in history that territories so pre-eminent in arts, learning, and civilization of a special kind should have fallen into the darkness again; and it is curious that the political and commercial interests of Europe in this sea-sundered continent should have so dwindled and died away.

There are two somewhat remarkable statements concerning the early exploration of other parts of Africa—one on the authority of Herodotus (iv., 42), who rested his assertion that it was surrounded by water except at Suez on a story that Nechos (the Pharaoh-Necho of 2 Kings xxiii. 29, &c.), king of Egypt, had sent some Phœnicians to sail from the Red Sea round Libya, and coming through the Pillars of Hercules (Straits of Gibraltar) into the Northern Sea (*i.e.* the Mediterranean) returned to Egypt. After a three years' voyage they accomplished their task. The other reported voyage of circumnavigation is attributed to Hanno, one of the enterprising rulers of Carthage, about 150 years prior to the visit of Herodotus to Egypt. Hanno undertook an exploratory and colonizing expedition through Hercules Straits into the Atlantic Ocean, taking with him 30,000 emigrants, whom he intended to settle along the coasts of the Western Sea. A translation of an account of Hanno's voyage from the Punic language into Greek is extant. From Pliny (v. 1) we learn that the Greek historian Polybius was commissioned by Scipio Æmilianus to explore the western shores of Africa about 138 B.C., but no correct statement of how far he went has been preserved. The Greek philosopher and historian Arrian, about A.D. 146, composed a Periplus of the Erythrean Sea between Arabia and India, on the one side, and Africa on the other, and gives in it much information regarding the navigation of the east coast of Africa, naming Rhapta, which is supposed to be the Arab settlement and seaport of Quiloa, in Zanzibar, on the south-east. From the places noted by the geographer Claudius Ptolemæus (161 A.D.), both the Carthaginians and the Romans may be regarded as having probably reached, in their exploration of the west coast, to 11° N. lat., though he thought that the Indian Ocean was an inland sea. He gives places along the line of a river running through the interior, which he calls Niger, and which, to a certain extent, agrees with the course of Park's Joliba or the Niger.

After the Arabs occupied Egypt they sent caravans across the desert to the Soudan, and from the merchants who engaged in this traffic they probably acquired some knowledge, vague and unsatisfactory enough, but still greater than the Greeks and Romans had, of the countries skirting the Sahara on the

south. By them it is stated that Ghanah, the capital of Negroland in the eleventh century, was situated on a great river, and was replaced in 1213 by Timbuctoo, then founded by the Moors.

At the beginning of the fifteenth century only about 600 miles of coast between Gibraltar and Cape Nun, in Morocco, were known; but shortly thereafter the Portuguese, by a persevering course of exploration, made known to Europe the nature and character of the whole coast of Africa. Besides this they gradually acquired, through information given by visitors to their settlements, some knowledge of the interior of the country; and in fact so close did their relations with the natives become, that a large population of mixed descent grew up around their commercial or political establishments, which were, and now are, pretty extensive. The Portuguese settlements are generally along the coast, with no definite inland limit. Their trade with the native tribes is said to be rather unregulated, even by the code of commercial morality, and though they have been nearly four centuries in possession they have neither developed the civilization of the African races, nor improved the physical state of the territories over which they claim rule.

Columbus, by trial voyages along the African coast, acquired that skill in navigation which he required for the working out of the great scheme of discovery he had planned —a scheme which he first unfolded to the Portuguese.

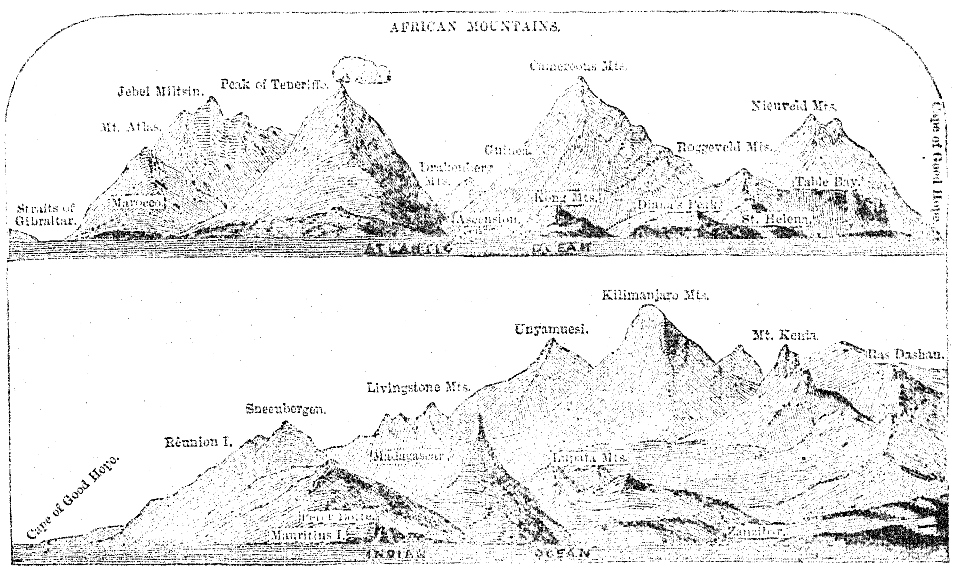
At length the atrocities of the slave-trade aroused the interest of the nations in the millions of Africa. Though Portugal had not accepted the proffered glory of acquiring the New World, it was not slow to profit by the discovery of Columbus. By the deportation of Africans to the mines and plantations of America the Portuguese enriched themselves, and continued as a commercial transaction what had hitherto been merely a sequel to the captivity of war. The agitation raised for the suppression of the slave-trade excited men about Africa and the woes its natives bore. Hardly was the Society for the Abolition of Slavery established in 1787 than there arose another in 1788 for the exploration of inner Africa. Then began that series of explorations in which Bruce, Mungo Park, the Landers, Hugh Clapperton, Horneman, Oudney, Denham, Laing, and other British enthusiasts carried on with marvellous energy and adventurousness the design—inaugurated by the African Association, and passed on from them to the Geographical Society—of surveying the entire stretch of the seemingly simple and compact structure of this large part of the Old World. The exploring expeditions of Caillié and Du Chaillu, Andersson, Nachtigall, and Rohlfs also deserve mention. There next arose the zeal of missions: men became eager to carry the message of mercy to their fellow-men perishing for lack of the knowledge of the way of salvation; and to this there succeeded schemes of Christian colonization. Livingstone, Reheman and Krapf, Burton and Beke, Speke and Grant, Baker, Stanley, Cameron, Serpa Pinto and Emil Holab, Hore and Thomson, have all won renown for philanthropy, skill, daring, and usefulness in their several researches; while the International Association for the opening up of Africa has formed itself into a great corporation for the development of industry, commerce, knowledge, and righteousness in this hitherto "dark continent." Men of all nations are in union, seeking to requicken the "souls made of fire" of these "children of the sun," who have sunk so low and suffered so much. In due time, it cannot be doubted, the physiography of Africa will be as thoroughly known, and our information regarding it be as accurate, as that which we have concerning any of the other great mainlands of the globe. "The land of the midday sun" will then be civilized and prosperous, and develop an historical character in harmony with its geographical position, its structural configuration, and its physical features. Its mountains, valleys, rivers, plateaus, and lakes shall all find appropriate places in the allotment of work to be done in perfecting the destiny of that mighty continent, whereon history has large space yet to write the annals of many nations, and the fortunes of many colonial dependencies belonging to the states of other continents.

To present in brief space any complete and exhaustive description of the African continent, arranged so as to show its organic structure and the mutual dependence and subordination of its different districts, is impossible. That has tasked the genius of Ritter in the first book of his "Erdkunde," and has engaged the writers of thousands of volumes. All that may be done by us is to cast into a condensed form such an epitome of the facts known as may interest and inform; and may, perhaps, be suggestive of ideas which will conduce to the better understanding of more voluminous works having higher aims.

On looking at the map of Africa we are at once impressed with a sense of its compactness. It is a vast mass, almost completely inclosed in itself, uninfluenced by the insweep of the ocean, with scarcely any indents in its sea-board, and quite devoid of peninsular articulations. The angles of it are even, as it were, worn off into obtuseness, till its original triangular form seems as if it would modify itself into an ellipse. The uniformity of its coast-line makes contact with the sea possible only to residents on its margins, and causes little development of the art of navigation as an agency for that interchange of the gifts of nature which an ocean-carriage and sea-commerce facilitate. There can be little doubt that the impenetrability of Africa has tended largely to its comparatively stationary condition and its deficiency in that civilization which originates in the mutual and reciprocal influences of man on men, in the calling into operation the specific varieties of human faculties, and in the activity of those sympathies which act as correctives to the self-seeking of insulated men or societies. The solidity of its configuration impedes the operation of change on the plastic parts of its surface, and so makes impossible that variety of transitional differences which educes peculiarities of skill, requires particular aptitudes, and affords opportunities for genius, talent, or industry of special sorts. A rich and diversified life cannot be normally developed under such circumstances. In early ages, when the sea formed a dissociating rather than an associating influence on mankind, plains drew men together in small bodies and aggregated them into communities; but now the sea has become the highway of civilization and power, of commerce and intercourse, and the inland centres of trade, requiring long and toilsome overland journeys to reach them, have in a great measure lost their effect on the development of man. Africa requires river service and railways to bring it into relation with the sea—the commerce and the comity of nations.

Ritter regards mountain regions as the main trunks of a continent. By mountain ranges and river-courses the surface is separated by nature into districts and differing localities, having special phenomena, productions, and predominant influences. Africa may be distinguished into four regions, which may be taken as chief divisions, capable of being surveyed separately:—(1) High Africa, *i.e.* the main central tableland of the continent; (2) the terraces intersected by water-courses which descend from these highlands; (3) the plateaus of Atlas and Barca; and (4) the lowlands of North Africa, the Sahara and its surroundings. We may trace its highlands from a point a little to the west of Suez (Bahr-es-Suweis), which in Jebel Attaka reaches a height of 2600 feet. A series of mountain terraces rising into a highland chain of 7000 or 8000 feet, overlooks the west coast of the Red Sea, to which it keeps nearly parallel, through Egypt, Nubia, and Abyssinia. On the Talanta plateau of the latter hill-range is the Magdala fort (9000 feet), 120 miles south-east of Gondar, stormed and taken by the British troops 14th April, 1868. To these succeed the Mountains of the Moon—which from the time of Ptolemy's tables have always figured in African geography—named Ruwenzori by Stanley. Kenia (18,000 feet) and Kilimanjaro (20,000 feet) continue the Abyssinian tableland southwards between the Indian Ocean and the Great Lakes, where the Livingstone Mountains (9000 feet) wall in Nyassa, and the mass of mountains (6000 to 10,000 feet) discovered by Captain Speke form a crescent round the head of Tanganyika. Still further south are the Quathlamba, Maluta, and the Drakenberg ranges, with their *kopjies* (rocky hills) and *kloofs* (naturally cleft hill-paths and gorges). These steep abrupt mountains look forth to the sea-margin, extending several thousand feet below them to the Indian Ocean, to which

they send down many short, rapid streamlets. From their inner slope the river Orange derives its sources, the Ky and the Gariep, or the Vaal and the Orange, with their numerous affluents—Modder, Velsch, Vet, &c.—as they gather for their long journey of 1500 miles. The terraces which form Cape Colony have a background of these hills flanking them. These are known as they proceed westward as Stormberg, Zuurberg, Suueenwberg, Winterberg, Nieuveld, and Roggeveld. While the general average of these highlands may be 6000 feet, Cathkin Peak is 10,300 feet, and Compassberg about 8500 feet. Among the terraces of these hills are the phenomenal Karoos. These are immense tracts of barren tablelands, from 2000 to 3000 feet above the sea-level, composed of shallow beds of clay-soil resting on a substratum of slate-rock, much impregnated with alkaline matter, but owing to want of water waste and wild until after heavy rains, when they flush into luxuriant vegetation, which dies almost as quickly as it burst into flourish. The mist-clad Table Mountain (3582 feet), and the great bulkhead of the cliff-mass of the Cape of Good Hope (1000 feet in height), form the Atlantic terminus of these groups. The Atlantic coast from Cape Colony to the Bight of Biafra is also buttressed by a rocky wall of flat-topped, barren mountains—the Cameroons, a vast volcanic mass, on the summits of which, 13,120 feet high, craters, said to have been eruptive within the memory of man, surround the Bight itself, and greatly impede inland communication, though into it there flow the Niger or Quorra, the Calabars, Rio del Rey, Cameroon, and Gaboon. Some of the peaks of the Kong Mountains—through which the Quorra, the Gambia, the Rokell, and the affluents of the Senegal find a course—reach the snow-line between 9° and 10° N. lat. One chain of this plateau trends to the north-east, another north-west, and a third rises up over the lands of the Mandingoes, Foolahs, and Ashantees, and in the territory of Yarriba turns to the south-east. The Atlas ranges (Greater and Less) run

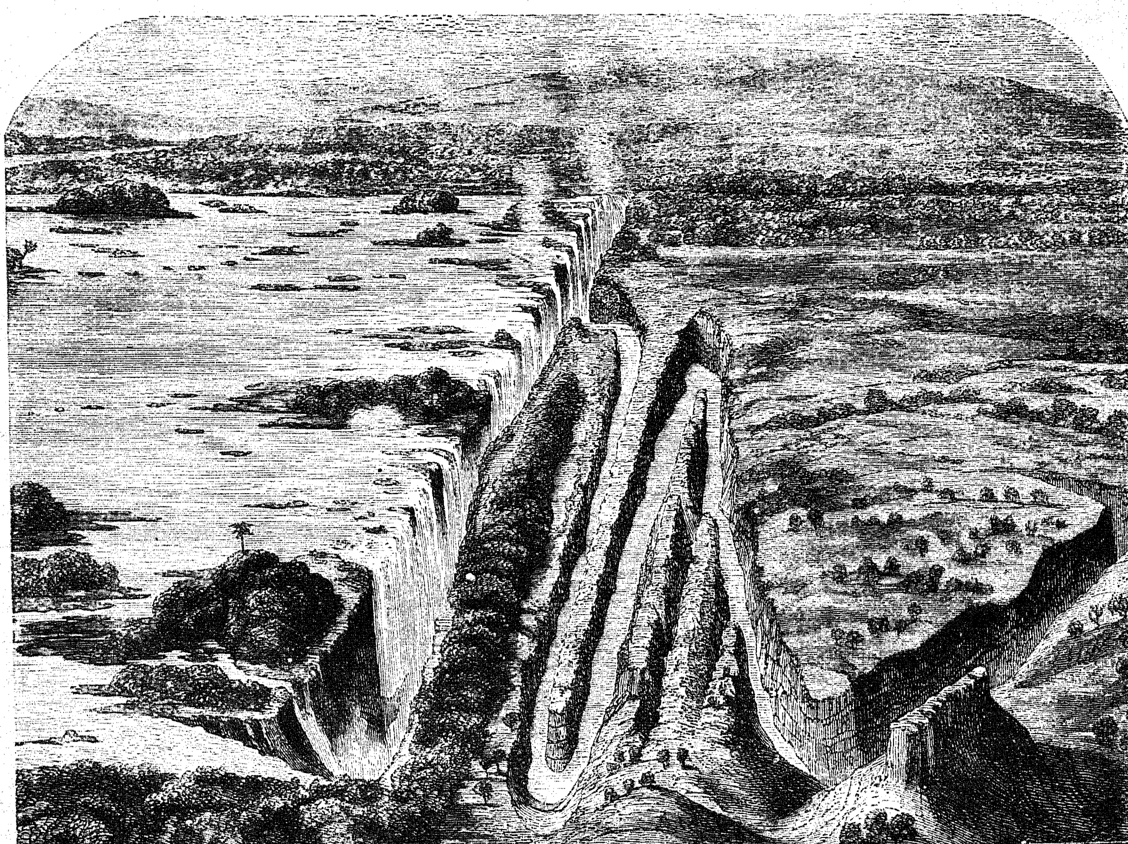


through Morocco, rising in Miltsin to 11,400 feet, and trend round to Barbary, covering the north-west of Africa with their peaks (13,000 feet), tablelands, and offsets. These pass into the Jebel-es-Soda or Black Mountains of Tripoli, and form the heights of Barca, in the western parts of ancient Cyrenaica, of whose hill-lands Herodotus furnished (iv. 168) an account. Within this engirdment of maritime mountain-land Africa seems to form a series of plateaus, in the hollow valleys of which vast lakes accumulate, and form the reservoirs of those cataract-vaulting rivers which drain off the inland rain-water, and have, perhaps, their great central knot in the mountain heights of Ulegga.

The inland lake-system of Africa is one of its most singular physiographical phenomena. Though not yet so thoroughly explored as to supply a perfected survey of its highland reservoirs, we may note some of the more prominent and remarkable. Those of the great equatorial land-locked fresh-water seas, as they might be called, perhaps require earliest mention:—Victoria Nyanza (with a little lake north-west of it named Lúta Nzigé, and more recently Albert Nyanza), is 3780 feet above the level of the sea. Its northern shore runs parallel to (but 20 miles north of) the equator. The N in these names signifies water. It is about 300 miles long by 200 in breadth, of no great depth, covered by fleets of canoes, which, however, never cross the lake. The Kitangălé is its chief feeder on the west, and the Kagera or Alexandra Nile, further west, is a tributary to it. From its northern side it issues by the Napoleon Channel, and the Ripon falls into the Albert Nyanza (97 miles long and 22 broad), whence, as the White Nile, it goes to seek its estuary in the Mediterranean at a distance of 3400 miles. About 200 miles south-west of Victoria Nyanza, nearly 2000 feet above the level of the sea, 400 miles long by 50 broad, and narrowing towards the north, Lake Tanganyika is entrenched by mountain walls, and shows a broad expanse of water gathered together in a hollow 2700 feet above the sea-level. It is fed by the Malagarazi River, and has its periodical outlet through Lukuga Creek to the Lualaba. Its waters are fresh and deep, and its shores are populous. The boot-shaped, Italy-like Nyassa or Star Lake, formerly called Maravi, 350 miles inland from the Mozambique coast, 1500 feet above the sea-level, 350 miles long, and nearly 40 broad, abounds in fish, is surrounded on the north by high granite hills, and on the south by many villages whose inhabitants are fishermen and agriculturists. It is the source of the Shiré, which, after a steep southerly course of 250 miles through a country productive of sugar and cotton, flows into the Zambezi. A small salt-water lake, Shirwan or Tumandua, 1800 feet high and surrounded by elevated land rising in Mount Zamba 7000 feet, is situated 30 miles south-east of Nyassa. Moero-kata, and its north and west companions Lanji, Kassali, Lolumba, &c., have not been satisfactorily explored, nor have the lakes which lie in the course of the Lualaba River and its tributaries, Ulenge, Lincoln, Bangweolo, &c., the last named of which, 3600 feet above the sea-level, is 150 miles long and 75 broad. Dembea, through which the Blue Nile flows, is 60 miles long and 25 broad. Of the great west central continental basin Lake Tchad is a fine, island-dotted, open sheet of water, 11,000 feet above the level of the sea, and covering an area of 16,000 square miles. It is fed by the river Tcharri from the south, and by the Waube, after a course of 400 miles, from the north. It is almost exactly

balanced in the south by Lake N'gami, 2500 feet above the sea-level. It is one of the most southern reservoirs of inland waters, and collects an extensive drainage through several sluggish streams as well as the western waters of the river Tioge, and communicates—as the mediæval geographers seemed to know—with the Zambezi or Zambesi River. On the summit of the watershed which separates the rivers running north-west from those flowing south-east, Lake Dilolo—whence the Leeba proceeds to the Zambezi—appears to have its place, and to give off from its waters affluents both to the north and south. A similar double issue is also stated to distinguish Kalagwe, which supplies to the south the waters of the Loapula, an eastern branch of the Zambezi, and to the north furnishes part of the contents of Tanganyika. Algeria, in its Sebkhas (or smaller deserts), has some small shallow salt lakes. Besides the lagoon (rather than lake) of Tunis, which runs by a Goletta (gullet or narrow channel) into the Gulf of Tunis, there are in Tunis only two remarkable lakes, bearing the name Biserta or Bensart—the *Palus Hipponites* and *Palus Sisaræ* of the ancients—about 30 miles distant from the capital. The one is clear and salt, about 10 miles long by 5 broad, the other fresh and turbid, the same in length and 3½ miles in width; and they are united by a channel about 2 miles long, varying in depth from 6 to 72 feet. They are well stocked with fish.

The river-system of Africa is not as yet thoroughly investigated and understood. It may be arranged and considered in three divisions:—(1) The Atlantic and Mediterranean, (2) the Indian Ocean, and (3) the inland. To the first belongs the Nile, "father of floods," whose valley is the type of fertility; Draa, from Morocco; Senegal and Gambia, from Senegambia; Niger, Quorra, or Joliba, from the Kong Mountains, by a circuitous route debouches into the Gulf of Guinea; Congo or Zaire, and the Lualaba, whose head-



The Victoria Falls.

stream is the Chambeze among the upper lakes, and whose issue is south of Loango; and Orange or Gariep, dividing Cape Colony from Namaqualand. Of the second the chief are—Webbe, Shebeli, or Haines, rising in Abyssinia, flowing through Somali, and pouring itself into a lake near the sea; Nigal; Jubb; Zambezi, which in its upper reaches is called the Lecambye, rushes through an immense rent in the basaltic rock, forming the marvellous series of the Victorian Falls or Mosiotunga (*smoke-sounds-there*), and dividing into many branches, flows beside a large delta into the ocean; Limpopo, from the Drakenberg range, after a curving course, finds its way into the ocean nearly opposite the south of Madagascar.

To the third belong those rivers which do not themselves reach the sea, but intercommunicate among the lakes, and most of which have been noticed in connection with the great lake system. The Yo, or Yeou, and the Shary are Bornuese rivers which fall into Lake Tchad. The Zonga in its south-east course, from about N'gami, forms rather a series of salt-hollows and marshes than a river. As a general rule, it may be stated that the central parts are not so much in want of water as of a proper distribution of it, for many of its streams are filled to excess during the winter rains, and in the summer drought are mere threads or scarcely covered channels. The Sahara district has its *wadis* or water-courses, but they are quickly drained off and dried. Torrents do, indeed, furrow the mountainous sea-ridges, but their courses are short and their waters rapidly rush, with the moisture they gather, down to the beach and into the ocean, and the kloofs down which they send their waters are left almost dry in fair weather.

The singular inland condition of Africa depends on its position and climatology, and nowhere else is the dependence of human development upon the complex arrangements of physiographical conditions so clearly seen. The relations of land and water, hill and valley, peninsular and insular access to the sea, outlet by river and inlet by sea-way, plateau and plain, mountain-chains and water-courses, winds,

waters, and land-masses, affect the vitality, constitution, opportunities, and even the aspirations of man, increase or limit possibilities of development, and call for differing powers and labours in order that men may become masters of their lives rather than be mastered by the climate and the scenes in which they live.

THE FRENCH LANGUAGE.—CHAPTER X.

THE VERB—NEGATION AND INTERROGATION—IMPERSONAL, INTRANSITIVE, REFLEXIVE, AND PASSIVE VERBS—EMPLOYMENT OF THE PARTICIPLES.

THE French verb is not only very manifold in its inflexions and conjugations, but it is likewise pretty much varied in its usages and idiomatic peculiarities. It might appear to be advantageous to the progress of the student that we should go on in this chapter with the consideration of the verbs, by classifying and explaining the changes which occur in those which do not closely adhere to the regular forms of conjugation, and are therefore called *irregular* verbs. We think, however, that it would be unwise just when the student had—as we presume he now has—acquired a fair working knowledge of the regular paradigms, to hurry him off into a set of minute directions concerning the different verbs which do not observe the forms of inflexion that he has studied. Instead of doing so, we shall allow the impression made by his studies to deepen in his mind, and shall take up some of those usages of the verb which are found to present difficulties, especially in the conversational employment of the French language.

Verbs may be used in *four* different ways: (1) *affirmatively*—I am, *Je suis;* (2) *negatively*—I am not, *Je ne suis pas;* (3) *interrogatively*—Am I? *Suis-je?* (4) *negatively* and *interrogatively*—Am I not? *Ne suis-je pas?*

The student has already seen, in the examples of the four conjugations, how the French verbs are used affirmatively. We now proceed to show him how they are used in the three other ways named.

NEGATION.

The regular verbs are conjugated *negatively* in the same way as the auxiliary verbs. In simple tenses, as *je parle*, I speak, *ne* is put before the verb and *pas* after it; in compound tenses, as *tu as parlé*, the *ne* is put before the auxiliary verb and the *pas* after it, between it and the participle—as *tu n'as pas parlé*, thou hast not spoken. In all present infinitives both *ne* and *pas* come before the verb. The *e* of *ne* is omitted before a vowel.

The following examples will suffice, but the student should also re-read the examples of conjugating the auxiliaries negatively:—

PARLER, CONJUGATED NEGATIVELY.

Ne pas parler,	*not to speak.*
N'avoir pas parlé,	*not to have spoken.*
Ne parlant pas,	*not speaking.*
N'ayant pas parlé,	*not having spoken.*
Je ne parle pas,	*I do not speak.*
tu ne parles pas,	*thou dost not speak.*
il ne parle pas,	*he does not speak.*
nous ne parlons pas,	*we do not speak.*
vous ne parlez pas,	*you do not speak.*
ils ne parlent pas,	*they do not speak.*
Je ne parlais pas,	*I was not speaking.*
Je ne parlai pas,	*I did not speak.*
Je n'ai pas parlé,	*I have not spoken.*
Je n'avais pas parlé,	*I had not spoken.*
Je ne parlerai pas,	*I shall not speak.*
Je n'aurai pas parlé,	*I shall not have spoken.*
Je ne parlerais pas,	*I should not speak.*
Je n'aurais pas parlé,	*I should not have spoken.*
Que je ne parle pas,	*that I may not speak.*
Que je ne parlasse pas,	*that I might not speak.*
Que je n'aie pas parlé,	*that I may not have spoken.*
Que je n'eusse pas parlé,	*that I might not have spoken.*
Ne parle pas,	*do not thou speak.*
qu'il ne parle pas,	*let him not speak.*
ne parlons pas,	*let us not speak.*
ne parlez pas,	*do not ye speak.*
qu'ils ne parlent pas,	*let them not speak.*

The following expressions are frequently used to denote various shades of meaning:—

Ne . . point, *not at all.*	Ne . . guère, *but little, scarcely.*
Ne . . plus, *no more.*	Ne . . personne, *nobody.*
Ne . . jamais, *never.*	Ni . . ni, *neither . . nor.*
Ne . . rien, *nothing.*	Ne . . que, *not . . but (only).*

EXAMPLES.

Je ne porte pas,	*I do not carry.*
Je ne parle point,	*I do not speak at all.*
Je n'admire plus,	*I no longer admire.*
Je ne chante jamais,	*I never sing.*
Je ne vole rien,	*I steal nothing.*
Je ne marche guère,	*I do not walk much.*
Nous n'aimons ni lui ni elle,	*We like neither him nor her.*
Je ne raconte que cela,	*I only relate that,* or *I relate but that.*

The following are other, though less common, forms of negation of which it may be advantageous to have a note:—*Ni moi non plus*, Nor I either; *Pas du tout, Point du tout*, Not at all; *Pas beaucoup*, Not much; *Pas très-bien*, Not very well; *Voulez-vous le faire ou non?* Will you do it or not?

Personne, rien, pas un, aucun, nul, ni, followed by *ne*, are sometimes placed before the verb; as *Personne n'est venu*, No one came; *Rien n'est plus utile que la science*, Nothing is more useful than science; *Pas un ne le croit*, No one believes it.

INTERROGATION.

To use a French verb interrogatively place the pronoun after the verb and connect them by a hyphen; in a compound tense put the pronoun between the auxiliary and the participle; *e.g.*:—

PARLER, CONJUGATED INTERROGATIVELY.

Parlé-je?	*do I speak?*
parles-tu?	*dost thou speak?*
parle-t-il?	*does he speak?*
parlons-nous?	*do we speak?*
parlez-vous?	*do you speak?*
parlent-ils?	*do they speak?*
Parlais-je?	*was I speaking?*
Parlai-je?	*did I speak?*
Ai-je parlé?	*have I spoken?*
Avais-je parlé?	*had I spoken?*
Parlerai-je?	*shall I speak?*
Aurai-je parlé?	*shall I have spoken?*
Parlerais-je?	*should I speak?*
Aurais-je parlé?	*should I have spoken?*

When the verb ends in a vowel and the pronoun begins with one, a euphonic *t* is put between them; as *Parla-t-il?* Did he speak?

If the subject of the verb is a *noun* put the noun first, and then the verb, with *il, elle, ils*, or *elles* between them, according to the gender and number of the subject-noun. Thus the English sentence, Is your father here? must be turned into French as if it were, Your father, is he here? *Votre père, est-il ici?* Have the children finished? *Les enfants, ont ils fini?*

There is a peculiar idiom employed in interrogation by the French which probably requires explanation. Instead of transposing the personal pronouns, we may sometimes use the phrase *Est-ce que?* Is it that? It is simply placed before the affirmative sentence. The word *que* loses its final *e* and takes an apostrophe (*qu'*) instead before *il, elle, ils*, and *elles*; as *Est-ce qu'il parle?* Does he speak? *Est-ce qu'ils ont parlé?* Have they spoken? This specific interrogative phrase must always be used before the first person singular when it contains only one syllable, in order to avoid the harsh sound which would necessarily be produced by placing *je* after the verb. The following frequently employed expres-

sions, however, are accepted as correct: *Ai-je?* Have I? *Suis-je?* Am I? *Dis-je?* Do I say? *Dois-je?* Do I owe? *Puis-je?* Can I? &c.

Take, for example, the affirmative sentence, *Vous allez*, You go, and prefixing to it the phrase *Est-ce que?* it is immediately transformed into the interrogative sentence, *Est-ce que vous allez?* meaning Is it [true, correctly reported, a fact, &c.] that you go? Do you go? or Are you going? Similarly, *Vous étudiez*, You study, becomes, by placing before it the interrogative phrase, *Qu'est-ce que vous étudiez?* What are you studying? This phrase is invariably placed before the subject—whether that is a noun or a pronoun—of the clause in which it appears; as *Est-ce que le voyageur dort?* Is the traveller sleeping? *Est-ce que*, however, is not to be employed after such introductory phrases as *où? combien? quel? lequel? quoi?* &c. In such cases we use, *Où allez-vous?* not *Où est-ce que vous allez?*

This idiomatic usage arose first as a means of avoiding some harsh collocations unpleasant to the ear, and some which it was almost impossible to pronounce, that occurred in the usual form of interrogation. If we use in the ordinary manner the interrogative form of the sentence *Je dors*, I sleep, namely, *Dors-je?* Sleep I? or Do I sleep? we find that we have an extremely disagreeable, in fact, an almost impossible sound to produce. To avoid this in some such instances this interrogative phrase was employed; so we say *Est-ce que je dors? Est-ce que je cherche? Est-ce que j'écoute? Est-ce que je mange?* &c., and the ease and simplicity of the form caused it to come into very frequent use.

There is no word used in French like the verb "to do" in the sentence, Do I speak? This verb is simply omitted in translating into French, just in the same way as *am*, the present of the verb "to be," is omitted in translating "I am speaking," which is translated merely by the present indicative —*je parle*. Notice also the accent put on *parlé* in the first sentence in the foregoing examples for the sake of euphony.

NEGATIVE INTERROGATION.

In simple tenses in the form of question put *ne* first, then the verb, then the pronoun, and last of all the second negative particle (*pas*, &c.) In compound tenses the participle is put last of all, after the second negative particle; *e.g.*—

Ne parlé-je pas?	*do I not speak?*
ne parles-tu pas?	*dost thou not speak?*
ne parle-t-il pas?	*does he not speak?*
ne parlons-nous pas?	*do we not speak?*
ne parlez-vous pas?	*do you not speak?*
ne parlent-ils pas?	*do they not speak?*
Ne parlais-je pas?	*was I not speaking?*
Ne parlai-je pas?	*did I not speak?*
N'ai-je pas parlé?	*have I not spoken?*
N'avais-je pas parlé?	*had I not spoken?*
Ne parlerai-je pas?	*shall I not speak?*
N'aurai-je pas parlé?	*shall I not have spoken?*
Ne parlerais-je pas?	*should I not speak?*
N'aurais-je pas parlé?	*should I not have spoken?*
Votre père, ne parlera-t-il pas?	*will not your father speak?*

In the next place, we have to notice several varieties of verbs which are distinguished more by their meaning than by their mode of inflexion, and which are characterized by peculiarities that make it advisable for us to group them under specific heads.

IMPERSONAL VERBS.

Impersonal verbs are only employed in the third person singular. They have no defined object, and derive their name from the fact that the action they express is not or cannot be performed by a person. In fact all really impersonal verbs express a phenomenon of nature; as *il gèle*, it freezes; *il pleut*, it rains.

The verb *faire*, to do, followed by an adjective, often is used idiomatically in impersonal phrases referring to atmospheric states; as *Il fait froid*, It is cold; *Il faisait chaud*, It was hot; *Il fait sombre*, It is dark; *Il faisait du vent*, It was windy; *Il fait clair de lune*, It is moonlight; *Il fait beau*, It is fair; *Il fait du brouillard*, It is foggy; *Quel temps fait-il?* What sort of weather is it?

Impersonal verbs which do not express a phenomenon of nature may be regarded as *accidentally* impersonal; such are *il arrive*, it happens; *il importe*, it concerns, &c. The genius of the French language admits a very frequent use of ordinary verbs as impersonal; *e.g. Il est arrivé un accident*, An accident has happened.

INTRANSITIVE VERBS.

Verbs are called intransitive, or neuter, when they denote a state, or when the action they express is confined to the subject or nominative; as *Je dors*, I sleep; *Je marche*, I walk. Most French neuter verbs, of which there are about six hundred, are conjugated with the auxiliary *avoir*. Some neuter verbs, however, take *avoir* or *être*, according to the sense.

The participles of those neuter verbs which take *être* for their auxiliary must agree both in gender and number with their subject; as *Je suis tombé* (*m.*) and *Je suis tombée* (*f.*), I have fallen.

The following neuter verbs take *être* in their compound tenses:—

Aller,	*to go.*	Éclore,	*to be hatched, to blow.*
Arriver,	*to arrive.*	Mourir,	*to die.*
Déchoir,	*to decay.*	Naître,	*to be born.*
Devenir,	*to become.*	Sortir	*to go out.*
Décéder,	*to die.*	Tomber,	*to fall.*
Entrer,	*to enter.*	Venir,	*to come.*

The compound tenses of these verbs are formed in the ordinary way: *je suis devenu*, I have become; *elles sont devenues*, they have become; *je serais devenu*, I should have become; *que je sois devenu*, that I may become; *être devenu*, to have become; *etant devenu*, having become, &c.

The following neuter verbs are conjugated with either *avoir* or *être*, according to the meaning they are intended to bear. When the *action* is chiefly to be considered *avoir* is used; when the *result* of it is most to be regarded *être;* as *Il a monté trop vite*, He went up too quickly; *Est-il monté?* Is he gone upstairs?

Accourir,	*to run to.*	Disparaître,	*to disappear.*
Cesser,	*to cease.*	Échapper,	*to escape.*
Changer,	*to change.*	Grandir,	*to grow.*
Croître,	*to grow.*	Monter,	*to go up.*
Déborder,	*to overflow.*	Partir,	*to set out.*
Demeurer,	*to tarry, to remain.*	Passer,	*to pass.*
Descendre,	*to descend.*	Rester,	*to remain.*

Many of these verbs, though in their nature neuter, may also be used transitively, *i.e.* as having a direct object; as *Descendre une montagne*, to descend a mountain.

Neuter verbs do not admit of an objective case after them. Therefore we may know practically that a verb is neuter when it will not make sense with the addition of *quelqu'un*, some one; *quelque chose*, some thing; *e.g. dormir*, *partir* are neuter, because we cannot say with propriety, *Je dors quelqu'un*, I sleep some one.

We give here specimens of the parts of two common neuter verbs—

PLEUVOIR, to rain.

Il pleut, *it rains.* *Pres. part.* pleuvant. *Past part.* plu.

Indicative—Il pleut, il pleuvait, il plut, il pleuvra, il pleuvrait.

Compound—Il a plu, il avait plu, il eut plu, il aura plu, il aurait plu.

Subjunctive—Qu'il pleuve, qu'il plût; qu'il ait plu, qu'il eût plu.

FALLOIR, to be necessary.

Falloir, *to be necessary.* No *Pres. part.* *Past part.* fallu.

Indicative—Il faut, il fallait, il fallut, il faudra, il faudrait.

Compound—Il a fallu, il avait fallu, il eut fallu, il aura fallu, il aurait fallu.

Subjunctive—Qu'il faille, qu'il fallût; qu'il ait fallu, qu'il eût fallu.

The following are examples of the use of *falloir:*—

Il faut que je sorte,	*I must go out.*
Il fallait que je sortisse,	*it was necessary for me to go out.*
Il faudra que je sorte,	*I will be obliged to go out.*
Il faudrait que je sortisse,	*I would be obliged to go out.*
Il aurait fallu que vous sortissiez,	*you would have had to go out.*
Il me faut,	*I want.*
Il vous faut,	*you want.*
Combien vous faut-il?	*how much do you want?*

REFLEXIVE VERBS.

The next class of importance bears the class-name of Reflexive or Pronominal Verbs. The former name is given to this class because the verbs included in it indicate actions at once performed and suffered by one agent—the agent of which is at the same time the agent and the object of the verb. The latter name they receive because they are conjugated throughout their entire inflexion with two pronouns of the same person—the former of which is the subject and the latter the object of the verb, direct when the reflexive verb is derived from an active verb, and indirect when the pronominal verb is formed from a verb neuter, or one used in a neuter sense. The double pronouns used in the conjugation of reflexives are *je me, tu te, il se, elle se, nous nous, vous vous, ils se, elles se.*

Some pronominal verbs are called reciprocal verbs, because they imply that the action indicated by the verb is performed by one agent, or more than one, mutually to or upon one another; as in *Vous vous plaisez,* You please each other; *Ils se comprennent,* They understand one another. Reciprocity, however, is only possible in the plural, and such verbs are necessarily only reflexive in the singular; as in *Je me comprends,* I understand myself.

The reflexive verbs are for the most part formed from other active verbs, and end, like all French verbs, in *er, ir, oir,* or *re.* So far as regards inflexion, *i.e.* the changing of the termination, there is no difference between a reflexive verb and any ordinary one. The four models of conjugation already given might serve for these verbs also, were it not for the three following differences:—

(1) A reflexive verb always takes one pronoun more than the active—viz. the accusative or dative of the personal pronoun expressing the object of the verb; as *Je blesse,* I hurt; *Je me blesse,* I hurt myself.

(2) The verb *être,* and never *avoir,* is used in compound tenses. In this case, however, *être* is translated into English by "to have;" as *Je me suis blessé,* I have hurt myself.

(3) The past participle generally agrees in number and gender with its subject; as

Il s'est blessé,	*he has hurt himself.*
Elle s'est blessée,	*she has hurt herself.*
Nous nous sommes blessés,	*we have hurt ourselves.*
Ces femmes se sont blessées,	*these women have hurt themselves.*
Vous vous êtes blessées,	*you* (fem.) *have hurt yourself.*
Vous vous êtes blessés,	*you have hurt yourself* [to a man.]

Reflexive verbs frequently have also in French what we would call in English a passive meaning, and imply the act of *becoming, growing, getting;* as *Mon habit est commencé, et il s'achève,* My coat is begun, and is finishing; *Accourez, la voilà qui se meurt,* Come, come, she is dying; *Le dîner s'apprête,* Dinner is getting ready.

Reflexive verbs are often used as impersonals, to express that an action is, was, or will be in progress or going forward; as *Il s'agit de,* &c., The question is to, &c.; *Il se fait de grands préparatifs,* Great preparations are going on; *Il s'est passé bien des années,* Many years have elapsed.

It is advisable to show the form taken by a reflexive verb, and we would suggest that the student should not only commit to memory the verb *se laver,* as it is briefly presented below, but should write it out in the full form of a verb of the First Conjugation. We have given it in this form that due attention may be directed to the method employed in making up the compound tenses.

Se laver, to wash one's self.

INDICATIVE MOOD.

SIMPLE TENSES.

Present.—Je me lave, tu te laves, il se lave.
Nous nous lavons, vous vous lavez, ils se lavent.
Imperfect.—Je me lavais, tu te lavais, il se lavait, &c.
Perf. Def.—Je me lavai, tu te lavas, il se lava, &c.
Future.—Je me laverai, tu te laveras, il se lavera, &c.
Conditional.—Je me laverais, tu te laverais, il se laverait, &c.

The compound tenses are thus formed, and the student should observe that (1) after *être* in reflexive verbs the participle agrees with the accusative pronoun; and (2) *être* is translated by "to have:"—

Perf. Indef.—Je me suis lavé, tu t'es lavé, il s'est lavé, &c.
Pluperf. Def.—Je m'étais lavé, tu t'étais lavé, il s'était lavé, &c.
Pluperf.—Je me fus lavé, tu te fus lavé, il se fut lavé, &c.

SUBJUNCTIVE MOOD.

SIMPLE TENSES.

Present.—Que je me lave, que tu te laves, qu'il se lave, &c.
Imperf.—Que je me lavasse, que tu te lavasses, qu'il se lavât, &c.

The compound tenses of the subjunctive are as follows:—

Perf.—Que je me sois lavé, que tu te sois lavé, &c.
Pluperf.—Que je me fusse lavé, que tu te fusses lavé, &c.

IMPERATIVE MOOD.

(This mood we set before our readers in two forms.)

(1) *Affirmatively.*—Lave-toi, qu'il se lave.
Lavons-nous, lavez-vous, qu'ils se lavent.
(2) *Negatively.*—Ne te lave pas, qu'il ne se lave pas.
Ne nous lavons pas, ne vous lavez pas, qu'ils ne se lavent pas.

As likely to be helpful in his further studies, we give an example of this verb conjugated (1) negatively, (2) interrogatively, and (3) both interrogatively and negatively, to show the position of the pronouns and the negative particles—

Negatively.—Ne pas se laver, il ne se lave pas, il ne s'est pas lavé.
Interrogatively.—Se lave-t-il? S'est-il lavé?
Interog. and *Neg.*—Ne se lave-t-il pas? Ne s'est-il pas lavé?

Exercise.—Write on the same form, *S'habiller,* to dress one's self; *se perdre,* to lose one's self; *se promener,* to walk; *se coucher,* to go to bed; *s'enrhumer,* to catch cold; *se dépêcher,* to make haste; *se vanter,* to boast; *se fier,* to trust.

PASSIVE VERBS.

The French language has, properly speaking, no passive verb. If it had, it would, like the Greek and Latin, have one form or word to express it. The so-called passive verb in French is simply the auxiliary *être* conjugated with the addition of the past participle of the verb that is to be conjugated passively. The passive verb stands in opposition to the active. The active verb represents its subject as acting, doing (something); the passive verb represents its subject as receiving the action done. Thus in *Le chat mange la souris,* The cat eats the mouse, *chat,* which is the subject, does the action expressed by the verb, and *la souris* is the direct object of the action of that verb. In the phrase, *La souris est mangée par le chat,* though the point of view is changed the sense is exactly the same; *la souris,* which in the former sentence is the direct object of the verb, becomes in the second the subject, and in the latter sentence *le chat* does not accomplish the action expressed, but itself receives the action. In the former *mange* is an active verb, because it indicates an action accomplished by the subject with reference to the object. In the latter *est mangée* is a passive verb, because the subject (*la souris*) suffers the action, instead of accomplishing it. A verb is therefore said to be active or passive according as it accomplishes or receives the action. Every passive verb has its active form, and every active verb ought to have its corresponding passive form. Thus we can in practice readily find out that a verb is active, for if it is we can turn it into a passive one, and that a verb is passive if we can turn it into an active one.

French passive verbs are formed of *être* and the participle past of the corresponding active verb. The participle past

must agree in number and gender with the subject. If *vous*, you, is used in reference to a single person, the participle retains its singular termination:—

Elle est admirée,	She is admired.
Vous êtes admirée,	You (*fem.*) are admired.
Vous êtes admirées,	You (*fem.*) are admired.
Vous êtes admiré,	You (*masc.*) are admired.
Vous êtes admirés,	You (*masc.*) are admired.
Elles sont admirées,	They (*fem.*) are admired.
Que je sois admiré,	That I (*masc.*) may be admired.

The French do not often make use of the passive verb. In English we very often employ the passive expressions—I am asked, She is liked, We were sought, You are esteemed, They are led, His orders have been finished, &c. In French, on the other hand, people prefer the employment of the active voice in similar cases, using *on* as the subject of their sentence. The word which would stand as subject in English, becomes in French the object of the verb, which in its turn takes the active form, and agrees with *on;* as *On me demande*, I am asked, *or* People ask me; *On l'aime*, She is liked, *or* People like her; *On nous cherchait*, We were sought, *or* People sought us; *On vous estime*, You are esteemed, *or* People esteem you.

The French prefer the use of a reflexive form instead of that of the passive. *La France est divisée en quatre-vingt-neuf départements*, is not so correct as *La France se devise en quatre-vingt-neuf départements.*

Similarly we have, *Cette maison se loue trop cher*, That house is let too dear; *Cette étoffe se vend à bon marché*, That cloth is sold cheap; *Cette règle se trouve dans la grammaire*, That rule is found in the grammar.

The student will find below an example of the conjugation of a passive verb used affirmatively.

PASSIVE VERB.

ETRE AIMÉ, to be loved.

Pres. infinitive,	Etre aimé,	*to be loved.*
Perf. infinitive,	Avoir été aimé,	*to have been loved.*
Pres. participle,	Étant aimé,	*being loved.*
Past participle,	Ayant été aimé,	*having been loved.*

INDICATIVE MOOD.

PRESENT TENSE.

Je suis aimé (aimée, *f.*),	*I am loved.*
tu es aimé,	*thou art loved.*
il est aimé, *m.*,	*he is loved.*
elle est aimée, *f.*,	*she is loved.*
nous sommes aimés,	*we are loved.*
vous êtes aimés,	*you are loved.*
ils sont aimés, *m.*,	*they are loved.*
elles sont aimées, *f.*,	*they are loved.*

IMPERFECT TENSE.

J'étais aimé,	*I was loved.*
tu étais aimé,	*thou wast loved.*
&c.	&c.

PERFECT DEFINITE TENSE.

Je fus aimé,	*I was loved.*
tu fus aimé,	*thou wast loved.*
&c.	&c.

PERFECT INDEFINITE TENSE.

J'ai été aimé,	*I have been loved.*
tu as été aimé,	*thou hast been loved.*
&c.	&c.

PLUPERFECT TENSE.

J'avais été aimé,	*I have been loved.*
tu avais été aimé,	*thou hast been loved.*
&c.	&c.

PLUPERFECT DEFINITE TENSE.

J'eus été aimé,	*I had been loved.*
tu eus été aimé,	*thou hadst been loved.*
&c.	&c.

FUTURE TENSE.

Je serai aimé,	*I shall be loved.*
tu seras aimé,	*thou shalt be loved.*
&c.	&c.

FUTURE PERFECT TENSE.

J'aurai été aimé,	*I shall have been loved.*
tu auras été aimé,	*thou shalt have been loved.*
&c.	&c.

CONDITIONAL MOOD.

PRESENT TENSE.

Je serais aimé,	*I should be loved.*
tu serais aimé,	*thou shouldst be loved.*
&c.	&c.

PAST TENSE.

J'aurais été aimé,	*I should have been loved.*
tu aurais été aimé,	*thou shouldst have been loved.*
&c.	&c.

IMPERATIVE MOOD.

Sois aimé,	*be thou loved.*
qu'il soit aimé,	*let him be loved.*
soyons aimés,	*let us be loved.*
soyez aimés,	*be ye loved.*
qu'ils soient aimés,	*let them be loved.*

SUBJUNCTIVE MOOD.

PRESENT TENSE.

Que je sois aimé,	*that I may be loved.*
que tu sois aimé,	*that thou mayst be loved.*
&c.	&c.

IMPERFECT TENSE.

Que je fusse aimé,	*that I might be loved.*
que tu fusses aimé,	*that thou mightst be loved.*
&c.	&c.

PERFECT TENSE.

Que j'aie été aimé,	*that I may have been loved.*
que tu aies été aimé,	*that thou mayst have been loved.*
&c.	&c.

PLUPERFECT TENSE.

Que j'eusse été aimé,	*that I might have been loved.*
que tu eusses été aimé,	*that thou mightst have been loved.*
&c.	&c.

Passive verbs are conjugated affirmatively, negatively, interrogatively, &c., nearly in the same manner as active verbs.

PARTICIPLES.

A participle is a word of twofold power. It partakes in part of the nature of a verb and of that of an adjective. (1) It has both the signification and governing power of a verb; as *Des enfants aimant l'étude*, Children loving study; *Ayant reçu votre lettre*, Having received your note. And (2), like an adjective, it expresses the quality or state of the persons or things to which it refers; as *Un champ labouré*, A ploughed field; *Une fille chérie*, A beloved daughter.

There are two sorts of participles: (1) the participle present, ending in *ant*, as *aimant, finissant,* often preceded by *en*, and always invariable when used as a participle; and (2) the participle past, which has various terminations, like an adjective, to indicate gender and number.

Present participles will often be found varying to indicate gender and number, but in this case they are always used as *adjectives*, more to express a state than an action. The following examples will show the difference in usage of present participles having government, being (1) participles, and (2) verbal adjectives:—

PARTICIPLES PRESENT.	ADJECTIVES.
Des enfants obéissant à leur maître	J'aime les enfants obéissants.
Une mère aimant sa famille.	Une mère aimante.
Des bruits alarmant les ésprits.	Des bruits alarmants.
Des enfants caressant leur mère.	Des enfants caressants.
Des esclaves suppliant le maître.	Une posture suppliante.
Une plainte touchant les cœurs.	Une plainte touchante.

Past participles may or may not, according to circumstances, agree in gender and number with the noun or pronoun to which they relate. The rules which govern the usage of the past participle are as follows:—

The past participle, when joined with the verb *être*, always agrees with the subject or nominative; as *Mon père est aimé*,

My father is beloved; *Mes frères sont aimés*, My brothers are beloved; *Ma mère est aimée*, My mother is beloved; *Mes sœurs sont aimées*, My sisters are beloved.

The past participle, joined with the verb *avoir*, only agrees with the object or accusative when the object is placed before the verb. The object or accusative case is always one of the pronouns *me, te, se, nous, vous, le, la, les*, or the relative pronoun *que*; as *La maison que j'ai achetée*, The house which I have bought. If, however, the object is placed after the verb the participle is invariable; as *J'ai acheté une maison*, I have bought a house; *Nous avons acheté des maisons*, We have bought houses; *Cette femme s'est voilé la tête*, This woman has veiled her head; *J'ai reçu une lettre*, I have received a letter.

It requires besides to be observed that the past participle is invariable (even though preceded by its object) when it is followed by a present infinitive, if the object do not perform the action; as *Les comédies que j'ai vu jouer*, The comedies which I have seen played; *Les châteaux que j'ai fait construire*, The castles that I have caused to be builded. But if the object perform the action expressed by the infinitive, the participle must agree with it; as *Ces acteurs sont bons, je les ai vus jouer*, These actors are good, I have seen them play.

EXERCISE.

Read the under-given paragraph carefully; then (1) arrange all the nouns in a column; (2) opposite each noun write its plural in full; (3) mark off, by a reference to the numbers contained on p. 112, the rule according to which the plural is formed; and (4) gather into groups all those which form their plurals in a similar manner.

L' univers est l'ouvrage de Dieu. La terre, l' eau, l' air,
The universe is the work of God. The earth, the water, the air,
et leurs habitants, les plantes qui *recouvrent* la terre, les
and their inhabitants, the plants which overspread the earth, the
astres qui *brillent* dans le ciel, le vent, la pluie, la rosée, la
stars which shine in the sky, the wind, the rain, the dew, the
neige, la glace, la grêle, la foudre, le tonnerre, *sont* une preuve
snow, the ice, the hail, the lightning, the thunder, are a proof
de sa bonté, de sa grandeur, et de sa puissance. L'homme
of his goodness, of his greatness, and of his might. Man
surtout, la plus belle des créatures, le roi de la
above-all, the most excellent of-the creatures, the sovereign of the
création, *est* la preuve éclatante de l' existence d'un Dieu qui
creation, is the proof striking of the existence of a God who
parle aux hommes dans l' orage et dans la tempête ainsi
speaks to men in the storm and in the tempest as-well
que dans sa Parole.
as in his Word.

Find (1) the nominatives to the verbs which are printed in italics, and (2) the part of the verb which is used. (3) Observe that the verb agrees with its nominative in number and person, and see that each relative pronoun agrees with its antecedent by (4) underlining the antecedent.

The following paragraph will explain the pronunciation of each of the words in the above sentences, according to the plan laid down in Lesson II. (page 25), which should be frequently re-read. Remember that in pronouncing words of more than one syllable no more emphasis must be put on any one syllable than is put on all the others. Notice how many letters there are which are not sounded in pronouncing French words.

L'oo-nee-ver ay l'oo-vraj dĕ Deŭ. La terr, l'ō, l'ayr, ay loor-s ab-ee-tan, lay plant kee rĕcoovr la terr, lay-s astr kee breel dan lĕ syel, lĕ ven, la plwee, la ros-ay, la nayj, la glas, la grayl, la foodr, lĕ ton-nerr, sŏn oon proov dĕ sa bon-tay, dĕ sa gran-door, ay dĕ sa pwees-sans. L'ŏmm soor-too, la ploo bell day crĕ-ă-toor, lĕ rwŏ dĕ la crĕ-a-secon, ay la proov ĕ-cla-tant, dĕ l'ex-ees-tans d'ŭn Deŭ kee parl ō-s ŏmm dan l'ŏ-raj ay dan la tem-payt an-see kĕ dan să Par-ōl.

READING LESSON.

We have now reached that stage at which we may profitably begin to read, not brief, meagre, and isolated phrases, but good, well-formed, and properly constructed sentences, dealing with subjects of real interest, and yet quite simple alike in their matter and their form. We purposely select some sentences of a kind for which the French language is peculiarly famous and specially well suited. The following definitions contain—as the observant reader will notice at once—a large number of words with the meaning and even with the orthography of which he is already pretty familiar, as they are in most cases derived from the same classical sources as those from which similar words in our own language are taken. The student who wishes to make the best use of the reading lesson now before him will find it advisable to proceed somewhat after the following fashion—viz. (1) Write in columns opposite each other all the words in this lesson which are *precisely* alike in orthographical form with English words, and notice how similar their signification is; (2) in the same way write out lists of those which are *nearly* alike, and that the points of difference may be distinctly kept in view underline in the French the letters in which they differ; and (3) write out a similar list of those which are *quite unlike* one another, and place in an opposite column the meanings attached to them in the translation. They will thus fall into groups of words (1) known and familiar, (2) partially known, and (3) new and hitherto unknown. Having done this recur to the lesson again, and (1) underline all the nouns, marking each with *m.* or *f.*, according to their gender; (2) inclose in parentheses all the articles preceding these nouns, and observe how they agree in number and gender with their nouns; and (3) draw a slightly curved line above each adjective, and notice (*a*) the place it occupies and (*b*) its agreement. In the next place turn attention to the pronouns, and compare them with the nouns to which they refer or for which they stand. If there is any difficulty in knowing the pronouns under any of their inflected forms or relations, a solution will easily be reached by looking the word up in Chapter VII., pp. 307–8. After this has been done search out the verbs, notice in them the terminations, and turn over to the table of conjugations, if there is any need, to make sure of the mood, tense, number, person, &c., of each.

When by these means a familiar acquaintance with the single words and their relations and meanings has been gained, (1) commit the several sentences to memory; (2) write them out from memory, leaving space between the several lines, into which (3) insert interlinearly the best translation you can give. Next write out the translation and interline it with the French from memory. Diligent and careful comparison of the exercises done with the reading lesson will enable the student readily to know, and therefore to correct, any errors that may have been made.

As it is quite possible that a difficulty may be felt in pronouncing the French in reading, the student should turn to Chapter II., on "The Elements of Pronunciation," pp. 22–26, and whenever a point on which he feels some hesitation occurs, (1) read over the passage relating to the letters involved and their combinations; (2) pencil above or below them the sounds given as equivalents; and (3), observing carefully the *elisions* and the *liaisons* occurring in the sentence, sound out the phrase or sentence fully and clearly, seeing that it is as pleasing to the ear as possible, and by and by timidity will vanish, and the power of speaking—acquired by frequency of repetition—will soon become facile.

L'arithmétique est l'art de calculer par des nombres; et malgré la grande variété de ses applications, elle ne consiste qu'en quatre opérations—l'addition, la soustraction, la multiplication, et la division.	Arithmetic is the art of calculating by numbers; and notwithstanding the great variety of its [practical] uses it only consists of four operations—addition, subtraction, multiplication, and division.
La botanique est la partie de l'histoire naturelle qui traite des végétaux. Elle les distribue par classes, et en décrit la structure et l'usage.	Botany is that portion of natural history which treats of plants. It arranges them according to classes, and describes their structure and use.
La géographie est la science qui nous fait connaître les parties constituantes du globe et leur distribution en parties de terre et d'eau. Elle nous enseigne aussi les limites et bornes des pays et leurs particularités naturelles et politiques. Elle est l'*œil* et la *clef* de l'histoire.	Geography is the science which enables us to know the constituent portions of the globe and their arrangement into portions of land and of water. It teaches us also the limits and boundaries of countries and their natural and political peculiarities. It is the *eye* and the *key* of history.

La géologie porte ses investigations dans la structure du globe, et en classe les antiques débris par ordre de siècles.	Geology carries its investigations into the structure of the globe, and classifies the ancient remains thereof in order of eras.
La géométrie est cette science sublime qui nous enseigne les rapports des grandeurs et les propriétés des surfaces. Dans une acceptation plus large, elle est la science de la demonstration. Elle renferme la plus grande partie des mathématiques, et on la préfère généralement à la logique dans l'enseignement de l'art de raisonner.	Geometry is that sublime science which teaches us the relations of magnitudes and the properties of surfaces. In a wider acceptation it is the science of demonstration. It includes the greater part of mathematics, and people in general prefer it to logic in the teaching of the art of reasoning.
L'histoire est le récit des faits et des événements passés étendu à tous les siècles et à toutes les nations. Elle est le guide de l'homme d'état et l'étude favorite du savant éclairé. Elle est l'école commune du genre humain, également ouverte et utile aux princes et aux peuples.	History is the narrative of the past deeds and events, extended to all ages and to all nations. It is the guide of the statesman and the favourite pursuit of the enlightened scholar. It is the common school of the human race, equally open and useful to princes and to peoples.
La logique est l'art d'employer efficacement la faculté de la raison dans la recherche de la vérité, et d'en communiquer le résultat aux autres.	Logic is the art of using effectively the faculty of reason in the search for truth, and of communicating the result of it to others.

NATURAL PHILOSOPHY.—CHAPTER XIV.

ACOUSTICS.

SOUND—ITS PROPAGATION IN AIR—ITS INTENSITY—TRANSMISSION THROUGH TUBES—REFLECTION—ECHOES—REFRACTION AND DIFFRACTION OF SOUND—ITS VELOCITY IN AIR—TRANSMISSION THROUGH LIQUIDS—VELOCITY IN GASES—DOPPEL'S PRINCIPLE—TRANSMISSION OF SOUNDS THROUGH SOLIDS—EFFECT OF MOLECULAR ARRANGEMENT—SPEAKING AND EAR TRUMPETS—THE STETHOSCOPE—SYREN—LENGTH OF SOUND-WAVES—VOICE—LIMIT OF PERCEPTIBLE SOUND—TUNING-FORK—PITCH—MUSICAL NOTES AND INTERVALS—DIATONIC AND CHROMATIC SCALES—EQUAL TEMPERAMENT—MUSICAL NOTATION.

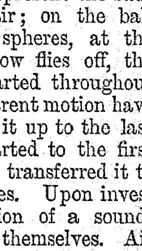
THAT branch of physics which relates to the study of sounds and the vibrations of elastic fluids forms the province of the science of Acoustics. *Music* considers sounds with reference to the pleasurable emotions they may excite; *acoustics* investigates the laws of the production, transmission, and comparison of sounds, as well as the physiological question of the perception of sounds.

The ear, the human organ of hearing, consists of several parts, which have been described in PHYSIOLOGY, Chapter VII., page 422.

Sound is the sensation conveyed by means of motion to the brain through the cavity of the ear by the auditory nerve. By the employment of the term *motion*, it is not to be understood that the nerves themselves move, but motion as applied to their molecules or particles. The rapidity of this motion imparted to the molecules of the nerves has been determined by Helmholtz and Du Bois Raymond to be about 93 feet a second.

All sounds are not identical; they present differences which enable them to be distinguished, compared, and their relations determined. Sounds are distinguished from *noises*. The distinction between a noise and a musical sound is that *noise* is either a sound of too short a duration to be determined, like the report of a cannon, or is produced by an *irregular* succession of sonorous shocks, such as the noise of waves or the rolling of thunder. A *musical sound* is that which produces a continuous sensation, caused by a rapid succession of sonorous shocks following each other at *regular* intervals of time. The musical hum from a humming-top is due to the rapid succession of shocks delivered in uniform intervals to the air as it impinges against the edge of the hole cut in the circumference of the top. The more rapid the speed of the top, the higher the tone produced. A toothed wheel in rapid rotation produces a musical note, the teeth successively delivering the shocks to the air in uniform intervals. In the same way a musical note may be produced by puffs of air or steam rapidly and uniformly delivered. Sound is always the result of rapid oscillations imparted to the molecules of elastic bodies, when the state of equilibrium of these bodies has been disturbed either by a shock or by friction. For instance, when a small bladder of gas is exploded in a room a noise is produced which is propagated through the air to the ear in the following manner:—On the first explosion of the gas heat was produced, and the stratum of air immediately surrounding the bladder expanded suddenly, imparting this acquired motion rapidly to the next stratum of surrounding air, while the air originally set in motion returns to rest. The second stratum of air in the same manner imparts its received motion to a third, and in its turn also comes to rest, and so on, each successive stratum of air picking up the motion of the previous one, and transmitting it forward to the next in succession. The motion so transmitted is propagated forward in the manner of a *wave* through the air, the forward motion of which is independent of the motion of the particles of air constituting the wave; for while the wave itself progresses forward with considerable velocity, the particles of air constituting that wave individually make only a very minute movement to and fro, returning afterwards to rest in their original position. This propagation forward of a sound-wave may be further illustrated, and the apparent rest of the molecules of air constituting the wave clearly presented, by taking a dozen or more glass balls or marbles, and placing them in contact with each other in a row upon a board in which a straight groove has been cut to keep them in position. The glass balls may represent the particles of air through which the sound-wave is transmitted. When the end ball is removed a little distance from the others, and rolled forward, the impact of this ball will represent the sudden expansion of the first particles of air; on the ball striking the first of the series of glass spheres, at the moment of contact the last ball of the row flies off, the motion of the rolling ball having been imparted throughout the entire series of balls, which without apparent motion have transmitted it through the series, delivering it up to the last ball, which flies off; thus, the motion imparted to the first was delivered up to the second, which again transferred it to the third, and so on to the end of the series. Upon investigation of the manner of the propagation of a sound-wave, certain important principles present themselves. Air is an elastic fluid capable of expansion and compression; consequently in a wave of sound each successive particle of air, when impinging upon the next adjacent particle, in delivering up its motion, first becomes compressed, and in the recoil after parting with its motion becomes expanded by virtue of its elasticity; and the more rapid this delivery and recoil, or the greater the elasticity of the air, the greater is the velocity of propagation of the sound-wave. A sound-wave consists therefore of two portions, in one of which the air is *compressed*, or of greater density, and in the other the air is *expanded*, or of less density. The two essential constituents of every sound-wave are therefore a *condensation* and a *rarefaction* of the air; without these conditions for its propagation sound cannot exist. The presence of an elastic medium is therefore necessary for the propagation of sound. This may be demonstrated by placing a small metal bell, which is continually struck by a hammer through the agency of clockwork or a musical box, under the receiver of an air-pump. As long as the receiver is full of air its sound can be distinctly heard, but as the air is exhausted the sound in proportion becomes feebler. If, when the vacuum is nearly completed, the receiver is filled with hydrogen gas, the specific gravity of which is fourteen times less than that of air, no variation of the sound will occur; but on further exhausting the receiver a very perfect vacuum is obtained, and the striking of the hammer on the bell (fig. 1) is now inaudible, although the hammer is seen in motion. As the air is again admitted to the receiver the bell once more begins to sound, gradually stronger and

Fig. 1.



Bell in Vacuum or Hydrogen.

stronger as the admitted air becomes more dense, until the ringing of the bell is as clear as it was before exhaustion was commenced.

It was observed that the admission of the hydrogen gas into the nearly exhausted receiver did not intensify the sound of the bell. This arose from the gas being much more mobile than air, so that the production of sonorous waves was attended with greater difficulty. Consequently a ratio of vibration which would produce sound-waves in the one, may be incompetent to produce them in the other, as a certain sharpness of shock is required to produce the necessary condensation and rarefaction which constitute a wave of sound. Various causes are found to influence the force or *intensity* of sound. At great elevations in the atmosphere, where the air is less dense, sound is sensibly diminished in loudness. A pistol fired at the top of Mont Blanc is no louder than an ordinary cracker at the foot of the mountain. Other causes are the distance of the sounding body, the *amplitude* of the vibrations of the molecules of air, the direction of the currents of air, and the vicinity of other sounding bodies. Again, as with all motion, so the motion of sound is weakened by its transmission from a light medium to a heavy one. Before the receiver of the air-pump was placed over the bell its sound was loud and clear, but as soon as the receiver inclosed it a large portion of its sound was cut off, because the vibrations had first to be communicated to the denser glass of the receiver, and by it again to the outside air. The intensity of a sound depends therefore on the density of the air in which it is generated, and not upon that of the air in which it is heard. If two cannons, equally charged with powder, be fired, one from the top of a mountain and the other at its base, that discharged in the denser air below will be heard at the summit of the mountain, while the other fired in the more rarefied air is inaudible below.

The following are the laws which regulate the intensity of sound:—

(1) *The intensity of sound is inversely as the square of the distance of the sonorous body from the ear.*—This law has been determined by calculation, but is also verified by experiment. Thus, if the spherical shell of air surrounding an exploded gas bladder has a radius of 1 foot from the centre of explosion, a shell of air of the same thickness, but of 2 feet radius, will contain four times the amount of matter; if of 3 feet radius, nine times; if of 4 feet radius, sixteen times, and so on, so that the quantity of matter set in motion augments as the square of the distance, and the intensity of sound diminishes in the same proportion. Again, assume that four bells of equal weight, struck by hammers also of equal weight and falling the same distance, are placed 40 yards from the ear, and that a similar bell is placed 20 yards from the ear, the sound produced by the single bell at the 20 yards is of equal intensity as that from the four bells at 40 yards struck simultaneously. Therefore for double the distance the intensity of the sound is only one-fourth. The distance at which sound can be heard depends on its intensity. The discharge of a volcano at St. Vincent was heard at Demerara, 300 miles distant, and the discharge of cannon at Waterloo was audible at Dover.

(2) *The intensity of the sound increases with the amplitude of the vibrations of the sonorous body.*—When a particle of air in a sound-wave is urged from its position of rest towards an adjacent particle, it is impelled forward, first with an accelerated motion, and then with a retarded one, as the force which first urged it forward is opposed to the resistance of the air, which at last stops the particle and causes it to resist. At one point of its movement the velocity of the particle is at its maximum. The space through which the air particle moves to and fro when the sound-wave passes it is called the *amplitude of the vibration.*

(3) *The intensity of sound depends on the density of the air in the place in which it is produced.*—This was illustrated when the bell was placed under the glass receiver of the air-pump, and also referred to in the discharge of cannon at the base and top of a mountain, and also in the case of hydrogen, which is about one-fourteenth the density of air. In carbonic acid, the density of which is 1·529, sound is more intense. The ticking of a watch is audible in water at a distance of 23 feet; in oil, $16\frac{1}{2}$; in alcohol, 13; and in air only 10 feet.

(4) *The intensity of sound is modified by the motion of the atmosphere and the direction of the wind.*—In a still atmosphere sound is always better propagated than when there is wind; in the latter case, for an equal distance, sound is more intense in the direction of the wind than in the contrary direction. Experiments made on the Elbe in 1881 demonstrated that the sound of a large Holmes' mechanical foghorn travelled with the wind $5\frac{1}{4}$ miles, but against the wind, at the same pressure, only $1\frac{3}{4}$ mile.

(5) *Sound is intensified by the proximity of a sonorous body.*—A stretched string vibrating in free air emits but a very feeble sound, but when set vibrating over a sounding board, as in the case of the violin, harp, or piano, its sound is intensified. This arises from the air in contact with the sounding board vibrating in unison with the string; hence the larger surface set in motion by the sounding-board augments the sound.

When a sound-wave is sent through a tube with a smooth interior surface, and confined to prevent lateral diffusion, the law that the intensity of sound is inversely as the square of the distance from the sonorous body does not apply, because the sound-wave may be transmitted to great distances with little loss of intensity. M. Biot observed the transmission of sound through the empty water-pipes of Paris, and carried on a conversation in a low whisper through a pipe 3120 feet in length; the discharge of a pistol into one end of the pipe extinguished a lighted candle at the other end. The weakening of sound becomes, however, very marked in tubes of large diameter, or where the sides are rough. The transmission of sounds through tubes was first used in England for *speaking tubes.* They consist of metal tubes of small diameter, passing from one room to another. A person speaking at one end of the tube is distinctly heard by a person with his ear placed at the distant end. Regnault has found by experiment that in straight cylindrical tubes the intensity of sound gradually diminishes with the distance, and that the distance at which it ceases to be audible is nearly proportional to the diameter of the tube.

By discharging a small pistol loaded with a gramme of powder into the open end of tubes of various diameters and lengths, the distance at which sound ceased to be heard, or to act upon a sensitive membrane stretched over the end of the tube, was ascertained. This membrane, which had a small metal disc on its centre, could be fixed across the tube at various distances, and when it began to vibrate made metallic contact with and closed a voltaic circuit in connection with a chronograph, so that the precise moment of vibration from the sound-wave was ascertained.

The limits of sound were as follows:—

1·159	metres*	in a tube of	0·108	metre diameter.
3·810	"	"	0·300	" "
9·540	"	"	1·100	" "

The principal cause of this loss of intensity is the friction against the sides of the tube.

When sound-waves are able to move freely they are propagated in the form of concentric spheres. When, however, they meet with an obstacle they follow the general law of all elastic bodies; that is, they *react* upom themselves, forming new concentric waves, emanating from a second centre on the other side of the obstacle. This phenomenon is what is termed the *reflection* of sound, and is subject to the two following laws:—*The angle of reflection is equal to the angle of incidence;* and, *the incidental sonorous wave and the reflected wave are in the same plane, which is perpendicular to the reflecting surface.* When a sufficient interval exists between a direct and a reflected sound the latter is heard as an *echo.* A very sharp sound, as the clap of the hands, can produce an echo when the reflecting surface is 55 feet distant; but for articulate sounds at least double this distance is necessary, for no person can pronounce or hear distinctly more than five syllables in a second. As the velocity of sound at ordinary temperatures is 1125 feet a second, in a fifth of that time sound would travel 225 feet, and if the reflecting surface is

* A metre is equal to 39·3708 inches.

112·5 feet distant, in going and returning it will travel through 225 feet. The time elapsing between the articulate and the reflected sound is therefore one-fifth of a second, so that the two sounds would not interfere, and the reflected sound would be heard as an echo. When the reflecting surface is less than 100 feet distant, the reflected sounds blend with the direct sounds, and a confused sound reaches the ear. This is what is sometimes called *resonance*, and is often observable in large rooms. Bare walls are very resonant, but curtains and drapery, which are indifferent reflectors, deaden the sound. To overcome the effects of resonance is often a very difficult acoustic problem for the architect. Sound, like light, is capable of being reflected several times in succession, forming *multiple echoes*. This is the case when two opposite and parallel surfaces or walls successively reflect sound, but the successive echoes become in turn more and more indistinct to the ear. An echo in the chateau of Simouelta, in Italy, repeats a sound thirty times. At Woodstock there is one which repeats from seventeen to twenty times. The effect of reflected sound in buildings is sometimes very curious. In the Bourse at Paris, when standing in the gallery, the voices of the multitude below mix with their echoes and reach the ear as a chaos of noise. In St. Paul's Cathedral it is impossible to hear distinctly music played upon the organ, the notes all blending with their echoes.

As the laws of reflected sound are the same as those of light and heat, the curved surfaces of roofs and ceilings produce *acoustic foci* similar to the luminous and calorific foci produced by concave reflectors, hereafter described. Whispering galleries are formed of smooth walls, having a continuous curved form. If the mouth of the speaker is presented to the wall at one point the voice is successively reflected from one point to the other until it reaches the ear of the listener at another and distant point. In the Whispering Gallery of St. Paul's the faintest whisper may be heard at the opposite side of the dome, but is not heard at any intermediate points. At the Colosseum, Regent's Park, a circular building of 130 feet diameter, now pulled down, Wheatstone found, on placing himself close to the upper wall, that a word was repeated a great many times, a single exclamation sounded like a peal of laughter, and the tearing of a piece of paper resembled the patter of hail. At Carisbrook Castle, Isle of Wight, a pin dropped into the well is heard striking the surface of the water at a depth of 210 feet.

The laws of the *refraction* of sound are the same as those for light and heat, and are the consequence of the retardation of motion suffered in passing from one medium to another of increased density. Hajech demonstrated this by using tubes filled with various liquids and gases, and closed by membranes; the membrane at one end was at right angles to the axis of the tube, while the other formed an angle with it. These tubes were placed in an aperture in the wall between two rooms, and the sound of a tuning-fork produced in front of the tube in one room was heard in various directions in the other, varying with the nature of the fluid or gas with which the tube was filled. (Accurate measurements determined that the sines of the angle of incidence and of refraction are in a constant ratio, which is equal to the ratio of the velocity of sound in the two media.) It is probably due to refraction that sound is propagated in a direction against that of the wind with less velocity than with the wind. The velocity of wind against the ground is considerably less than at a greater height. At 8 feet from the ground the velocity is double what it is at a height of 1 foot; hence the front of a condensed wave, originally in a vertical direction, becomes tilted upwards, with the lower part forward; and, as the direction of the wave-motion is at right angles to the front of the wave, the effect of the coalescence of a number of these waves directed upwards is to increase the sound in the higher region. The waves which travel with the wind being refracted downwards the sound is better heard.

A sound-wave is also capable of *diffraction*, or being bent round an obstacle interposed in its path, though as it diffuses itself in air at the back of the obstacle it is enfeebled in power. The effect of the diffraction of a sound-wave was noticed after the explosion of the powder magazine at Erith, on the Thames, in 1864. The village of Erith is some miles distant from the seat of the explosion, and not only were all the windows in the direction of the explosion broken, but it was observed that the windows turned away from this direct line suffered almost as much. In the church lead sashes were employed to glaze the windows, which, being flexible, enabled the windows to yield to pressure without serious fracture to the glass. As the sound-wave reached the church, which formed an opposing obstacle to its passage, it diverged right and left, and for a moment surrounded the building by a wave of intensely compressed air, every window in the church, front and back, being bent inwards. After compression the elasticity of the confined air within the church tended to restore the windows to their original condition, but the internal recoil being feeble in comparison with the force of the external pressure the windows retained their inward depression. Somewhat similar effects of diffraction were observed at the time of the explosion of the gunpowder barge in the Regent Park Canal, 1874; the sound-wave bent round houses, breaking windows away from the line of the explosion. At the hall, Primrose Hill, distant half-a-mile, not only was all the plate glass of the windows facing the explosion shattered, but the lofty windows, glazed with lead, in the concert-room at the back of the building, and away from the direction of the explosion, were all bulged inwards by external pressure.

The propagation of a sonorous wave is gradual; sound therefore requires an interval of time for its transmission from one place to another. The sound of thunder is only heard some time after the flash of lightning has been seen, although both the sound and the flash are produced simultaneously. The velocity of sound in air was experimentally determined with accuracy by Molt and Van Beck in 1823. Two hills near Amsterdam were selected as stations; their distance apart, determined trigonometrically, being 57,971 feet, or nearly 11 miles. Cannon were fired at stated intervals simultaneously at each station, and the time which elapsed between seeing the flash and hearing the sound was carefully measured by chronometers. As the velocity of the transmission of light is so enormous, this time could be taken as that which the sound required to travel between the two stations. The necessary corrections for barometric pressure, temperature, and hygrometric state being made, and eliminating the influence of the wind, the velocity as calculated gave 1092·78 feet per second in dry air at 0° C. and under a barometric pressure of 29·944 inches. The velocity of sound at zero may therefore be taken as 1093 feet, or 333 metres. This velocity increases as the temperature of the air rises; it may be calculated from the formula, $v=1093\sqrt{(1+0{\cdot}003665t)}$ for a temperature of $t°$, where 1093 is the velocity in feet at 0° C., and 0·003665 the coefficient of expansion for 1° C. The increase of velocity for every degree centigrade is nearly 2 feet, and is the same for all sounds, of whatever pitch. If some sounds travelled more rapidly than others the tune played by a band would not be heard at a distance without alteration, except in intensity. From calculations made by Earnshaw, and confirmed by observation, the velocity of sound is increased by loudness. During blasting operations at Holyhead, Mallet observed that the larger the charge of gunpowder used, and therefore the louder the report, the more rapid was the transmission of the sound. A 2000 lb. charge of gunpowder gave a velocity of 967 feet per second, while with a charge of 12,000 lbs. it was 1240 feet per second. The same augmentation of velocity has also been observed by discharging different weights of powder from a cannon.

For calculating the velocity of sound in gases, Newton gave a rule represented by the formula $v=\sqrt{\frac{e}{d}}$, in which v is the velocity of the sound, or the distance traversed in a second; e the elasticity of the gas, and d its density. Therefore, as expressed by this formula, *the velocity of sound in gases is directly as the square root of the elasticity of the gas, and inversely as the square root of its density*. The velocity of sound is also the same under any pressure, for by Boyle's law, although the elasticity increases with increased pressure, the density increases in the same ratio. As the measure of the

elasticity of a gas is the pressure which it sustains, if g be the force of gravity, h the barometrical height at 0° C., and δ the density of mercury at 0° C., therefore for a gas under ordinary atmospheric pressure at 0° C., $e = gh\delta$. If the temperature of the gas is increased from 0° to t°, its volume will increase from unity at 0° to $1+at$ at t°, a representing the coefficient of expansion of the gas. But as the density varies inversely as the volume, d becomes $d \div (1+at)$,

$$\text{or } v = \sqrt{\frac{gh\delta}{d}(1+at)}.$$

By substitution of the values in centimetres and grammes, $g=981$, $h=76$, $d=0{\cdot}001293$, and the value of v is 29,795 centimetres,* or 297·95 metres, which is less than the experimental result. Laplace gives as a reason for this variation the heat produced by pressure in the condensed wave; and if the formula be modified by the introduction of a constant for the specific heat of the gas for a constant pressure, and its specific heat for a constant volume, represented by e and e' respectively, the formula becomes $v = \sqrt{\frac{gh\delta}{d}(1+at)\frac{e}{e'}}$; the calculated numbers agree with the experimental results. The average value of this constant $\sqrt{\frac{e}{e'}}$ may be taken as 1·4. The physical reason for the introduction of this constant $\sqrt{\frac{e}{e'}}$ into the equation for the velocity of sound will be understood by considering that sound is propagated in air by a series of alternate condensations and rarefactions, that at each condensation heat is evolved which increases with the elasticity and rapidity with which each condensed layer of air acts upon the next, and that in the rarefaction of each layer the same amount of heat is abstracted, while its elasticity is diminished by the cooling. The effect of this diminished elasticity of the cooled layer is the same as if the elasticity of an adjacent wave had been increased, and therefore the rapidity with which this wave expands upon the dilated wave is greater; so that while the average temperature of the air remains the same, the heating which increases the elasticity, and the cooling which reduces it, both concur in increasing the velocity.

The velocity of sound in air being known, a means is afforded of measuring distances; thus, the number of seconds being counted which elapse between the flash of lightning and the roll of the thunder reaching the ear, multiplying this number by 1125, the distance in feet of the electrical discharge is found. The velocity of sound depends upon the nature of the gaseous medium through which it is propagated. If a gas which, under ordinary atmospheric pressure, is half as dense as air, is compared with air, and two precisely similar undulations are propagated in the two media, then, while the differences of pressure which give rise to the vibrations are the same in both, the mass to be moved is only one-half as large in the lighter gas, and the velocity of propagation of the sound-wave will be proportionally increased. This velocity varies inversely as the square root of the density, and knowing the velocity of sound in air, it may be calculated for other gases; thus, in hydrogen it will be $\frac{1093}{\sqrt{0{\cdot}0688}} = 4168$ feet. As the coefficient $\sqrt{\frac{e}{e'}}$ differs for various gases, this result is not always accurate. When each gas has its special value of $\sqrt{\frac{e}{e'}}$, the theoretical and observed results agree. The following are the velocities for various gases at 0° C.:—

Air, ...	1093	feet in a second.
Oxygen, ...	1040	"
Carbonic oxide, ...	1106	"
Hydrogen, ...	4164	"
Carbonic acid, ...	858	"
Olefiant gas, ...	1030	"
Chlorine, ...	677	"

* A centimetre is 0·3937 inch, a gramme is 15·4323 grains, and is the weight of a cubic centimetre of distilled water at 0° C.

The tone perceived by the ear on the *approach* of a sounding body is somewhat higher than the true one, and the converse takes place as it recedes from the ear; this rise and fall of tone is called *Doppler's principle*, and it is thus explained:—When both the ear and the sounding body are at rest, the ear perceives n waves in a second; but if the sound approaches the ear it will perceive a greater number of vibrations, in the same way that a man walking against a rain shower will meet with more rain drops than if he stood stationary, or a ship meets more waves when it sails through them than if it were at rest; and conversely the ear receives fewer vibrations when it recedes from the source of sound. In the first instance the effect is as if the sounding body emitted more vibrations in a second than it actually does, in the latter case fewer, so that as the sounding body approaches the note will seem higher, and as it recedes lower. If the distance the ear travels in a second towards the source of sound, which is assumed to be stationary, is d feet, and the wave-length of the tone is l feet, then there are $\frac{d}{l}$ waves in a second; or also $\frac{nl}{v}$, for $l=\frac{v}{n}$, where v is the velocity of sound. Therefore the ear receives not only the n original waves, but likewise $\frac{nd}{v}$ in addition. Consequently the number of vibrations which the ear perceives is $n' = n + \frac{nd}{v} = n\left(1+\frac{d}{v}\right)$ when the ear is approaching the source of sound, and $n' = n - \frac{nd}{v} = n\left(1-\frac{d}{v}\right)$ when the ear is receding from it. This alteration of tone as a sounding body approaches or recedes from the ear was investigated by Scott Russell on several English railways. The variation in tone may easily be observed in the sounding whistle of an express train passing through a station. At a speed of about 40 miles an hour the tone of the approaching whistle will be sharpened by a semitone above the true note, and flattened to the same extent as the train recedes from the station.

Doppler's principle may also be verified by attaching a long rod to a turning lathe, and fixing on the end of the rod a large glass sphere with a slit in the side. On rotating the sphere with a rapid uniform motion a loud humming is heard, producing a steady note from the uniform rotation. The pitch of the note will be higher or lower according as the observers' ear advances or recedes from the sphere.

The velocity of sound in liquids may be determined theoretically the same as its velocity in air. The subject was investigated in 1827 by Colladon and Sturm, who moored two boats at a measured distance in the Lake of Geneva. In one boat was a bell immersed in the water, and sounded by a lever having at one end a hammer to strike the bell, and at the other a lighted match for the ignition of gunpowder at the moment of sounding the bell. The other boat was furnished with an ear trumpet, the mouth of which was under the surface of the water, so that on the ear being applied to the tube, the time between the observed flash of light from the powder and the arrival of the sound could be accurately determined. By this method the velocity of sound through water was found to be 4708 feet in a second at a temperature of 8·1° C., or four times as great as in air. The calculated and observed velocities agree so closely as to prove that the changes of temperature produced by a sound wave in water have no influence upon the velocity. The velocity of sound varies in different liquids, and may be calculated by a formula analogous to that of gases; that is, $v = \sqrt{\frac{g\delta}{\mu d}}$, in which g and δ have their former values of gravity, and density of mercury at 0° C., μ represents the coefficient of the compressibility for the liquid, or its diminution in volume by the pressure of one atmosphere, and d is the density. As in the case of gases, the velocity augments with the temperature.

The values for other liquids than those given in the following table are uncertain, the coefficient for their compressibilities being at present undetermined. The greater the resistance which a liquid offers to compression the greater the velocity of sound through the liquid. In solids the

velocity of sound is greater as their elasticity, as compared with their density, is greater than in liquids. Biot found that when a bell was struck by a hammer at one end of an iron pipe 3120 feet long, two sounds were heard at the other end; the first was that transmitted by the tube, with a velocity x, the second by the inclosed air, y, and the interval between the sounds was 2·5 seconds. The value of x is obtained from the equation $\frac{3120}{y} - \frac{3120}{x} = 2{\cdot}5$; therefore the velocity of sound in the pipe is about nine times as great as that in air.

VELOCITY OF SOUND THROUGH LIQUIDS.

Liquid.	Temperature.	Ft. in a Second.
River water (Seine), . . .	13° C.	4714
" " . . .	30	5014
" " . . .	60	5657
Sea water (artificial), . .	20	4768
Solution common salt, . .	18	5132
" chloride of calcium,	23	6493
" sulphate of soda, .	20	5194
" carbonate of soda, .	22	5230
" nitrate of soda, . .	21	5477
Common alcohol, ...	20	4218
Absolute alcohol, ...	23	3854
Turpentine, ...	24	3976
Sulphuric ether, ...	0	3801

VELOCITY OF SOUND THROUGH METALS.

Metal.	20° C.	100° C.	200° C.
Lead, ...	4,030	3,951	...
Gold, ...	5,717	5,640	5,619
Silver, ...	8,553	8,658	8,127
Platinum, ...	8,815	8,437	8,079
Copper, ...	11,666	10,802	9,690
Iron, ...	16,822	17,386	15,483
Iron wire (ordinary), .	16,130	16,728	...
Cast steel, ...	16,357	16,153	15,709
Steel wire (English), .	15,470	17,201	16,394
Steel wire, ...	16,023	16,443	...

VELOCITY OF SOUND IN WOODS, FEET PER SECOND.

Wood.	Along fibre.	Across fibre	Along rings.
Pine, ...	10·900	4·611	2·605
Beech, ...	10·965	6·028	4·643
Oak, ...	12·622	5·036	4·229
Maple, ...	13·472	5·047	3·401
Elm, ...	13·516	4·665	3·324
Poplar, ...	14·050	4·600	3·444
Sycamore, ...	14·639	4·916	3·728
Fir, ...	15·218	4·382	2·572
Alder, ...	15·306	4·491	3·423
Ash, ...	15·314	4·567	4·142
Acacia, ...	15·467	4·840	4·436
Aspen, ...	16·677	4·297	2·987

The report of cannon is heard at greater distances than peals of thunder, because the sound in the former case is mostly transmitted through the earth, and in the latter through the air. The conductivity of sound in solids is illustrated by the filing of telegraph wire in repairing joints along a line—the noise may be heard miles distant by placing the ear against the wire. The toy telephone sold in the streets, consisting of a cord, the ends of which are attached to two thin wooden pill-boxes, is based upon this principle. The velocity of sound in wire may be determined by the formula $v = \sqrt{\frac{\mu}{d}}$, in which μ is the modulus of elasticity, d the mass in unit volume, which is equal to the specific gravity or the weight of the unit volume divided by the accelerative force of gravity, or $\frac{s}{g}$.

The transmission of sound through a solid depends greatly upon the arrangement of its molecules. If the body is homogeneous, sound is transmitted through it equally in all directions; but this is not so when the body possesses a definite structure. For instance, wood is a fibrous body, and both sound and heat are conducted through it with greater readiness along the direction of the fibres, and pass more freely across the ligneous layers than along them. Wood has therefore *three unequal axes* of sound and heat conduction, as determined by Tyndall, and which coincide with the axes of elasticity discovered by Savart. See preceding table. With all bodies which have their molecules arranged in different degrees of proximity in different directions, it will be found that there will be differences in the transmissions and manifestations of sound, heat, light, electricity, and magnetism through them.

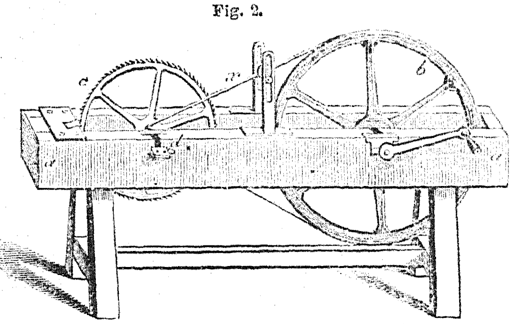
Speaking and ear trumpets depend for their effect upon the reflection of sound, and on its conductibility in tubes. The *speaking trumpet* consists of a conical brass or tin tube, terminating at one end in a wide opening, termed the *bell*, and furnished with a mouthpiece at the other. The augmentation of sound by the use of the speaking trumpet is scarcely understood. Leslie accounts for its effects in the following manner:—"The tube, by its length and narrowness, detains the efflux of air, and has the same effect as if it diminished the volubility of that fluid or increased its density. The organs of speech strike with concentrated force; and the pulses, thus vigorously excited, are, from the reflected form of the bell mouth, finally enabled to escape, and to spread themselves along the atmosphere." The effect of a speaking trumpet is the same, whether the metal tube be used simply or incased so as to prevent vibration. It is also heard at the same distance when the inner surface is lined with linen or woollen cloth to diminish the reflection; and the range of a cylindrical trumpet is the same as a conical one, as in either case a large column of air is set in motion. The instrument appears to have been known to the ancient Chinese. The modern speaking trumpet was invented in 1670 by Sir Samuel Morland, who constructed one by which a man's voice could be heard at $1\frac{1}{2}$ mile. The larger the dimensions of the trumpet the greater is the distance that the voice will carry. With one of the largest trumpets, tried at Deal Castle, the voice was conducted over the sea a distance of between 2 and 3 miles. The *ear trumpet* consists of a conical metal tube, one end of which terminates in a bell mouth, while the small end is introduced into the ear; for the sake of convenience the tube is often bent round to occupy a smaller space. The bell serves as a mouthpiece to receive the sound coming from the speaker's mouth, so that the instrument acts in the reverse way to that of the speaking trumpet. The sound of the voice is transmitted by a series of reflections to the interior of the trumpet, so that the sound-waves are concentrated on the ear, and produce a greater effect than the waves would have done if divergent.

The *stethoscope* is a most useful application of acoustical principles. Two sheets of thin india-rubber are attached to the rim of a hollow metal hemisphere; a stopcock is inserted in the rim between the two rubber sheets, so that the sheets can be inflated and blown out to form a double *convex* lens. A caoutchouc tube is attached to the back of the hemisphere, terminating in a horn or ivory which can be placed in the ear. When the membrane of the stethoscope is applied to the chest of a person, the action of the heart and the sounds of respiration are transmitted to the air of the chamber, and from thence to the ear by means of the flexible tube. If several tubes are fixed to the instrument as many observers may simultaneously examine the same person. Sometimes the stethoscope consists of simply a straight conical tube of wood, after the form of the ear trumpet.

Noise which is produced by an irregular succession of shocks produces on the auditory nerve a jotting and jarring sensation, while a musical sound flows smoothly and pleasantly, because the impulses received by the drum of the ear are perfectly regular, and succeed each other in the same intervals of time. Although the motions of a pendulum are perfectly uniform, they are much too slow to produce sonorous waves, which require that the body vibrating imparts much

sharper and quicker shocks to the air. In the humming bird this necessary rapidity is obtained, and in the flight of insects the rapidity of their vibrations produces a musical note. The production of a musical sound by a rapid succession of taps was first illustrated by Robert Hooke in 1681, and Savart invented an apparatus by which the absolute number of vibrations corresponding to any given note could be determined. The apparatus consists of two wheels (fig. 2) mounted on a frame, *a*, one of which is toothed, *c*, and connected with the

Fig. 2.

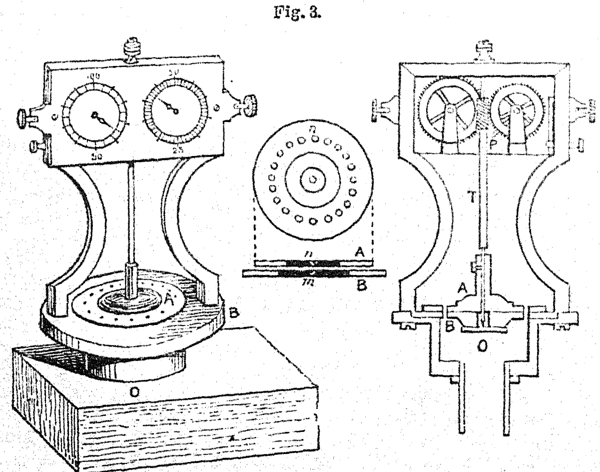


Apparatus for measuring the number of vibrations.

larger or driving wheel, *b*, by a strap and multiplying wheel, *x*, to obtain great velocity. In its revolution the teeth of the toothed wheel strike against a card fixed in position, causing the card to vibrate with every impact of a tooth. This wheel carries an index registering its number of revolutions, *d*. On slowly revolving the wheel the separate taps of each tooth against the card can be heard, their succession not being rapid enough to produce a continuous sound; but if the velocity be increased gradually the succession of shocks will assume the character of a musical note, rising higher and higher in tone as the velocity increases. The number of vibrations producing the note is ascertained by multiplying the number of teeth on the wheel by the number of revolutions in a minute; and by dividing by 60 the vibrations in a second are determined.

The *Syren* (fig. 3), another instrument for measuring the number of vibrations of a sounding body, was invented by

Fig. 3.



The Syren.

Latour. The principle on which it is constructed is that of rapidly dividing a current of air into minute puffs so as to produce a musical note, the pitch of this rising or falling as the rapidity of the succession of puffs of air in a given time is increased or diminished. The syren consists of a circular metal chamber O, the upper plate or disc, B, of which is perforated with a given number of holes *m*, so that if air is forced into the chamber it will escape through each of these holes. A second metal disc, A, similarly perforated and attached to a spindle for producing rapid rotation, is placed over the first disc, so that in one position of the upper disc all the holes of the lower disc, when the perforations do not coincide, will be closed, but if the upper disc be moved round a little the holes will exactly coincide, and be open. Consequently the upper disc when set rotating alternately opens and closes the perforations in the lower disc. By this arrangement the streams of air issuing from the perforations are cut up into numerous minute puffs or sonorous vibrations. The rapidity of vibration of any sonorous body is easily determined by this syren. The greater the speed of revolution of the upper disc, the higher the pitch of the note produced, and if the current of air from the chamber be sufficiently powerful, and the speed of the syren highly accelerated, the pitch rises higher and higher until finally the sound becomes inaudible to the ear, as the brain is incompetent to take up and translate into sound vibrations the rapidity of which exceed a certain limit. As the number of holes in the disc of the syren is known, as well as the speed of its revolution, the number of puffs or vibrations of the air necessary to produce a note of any given pitch is obtained by calculation. For example, assume the holes in the disc to be 18, equivalent to 18 puffs of air or vibrations in a revolution, and the revolutions of the upper disc to be 1780 in a minute; then, 18×1780, or 32,040, will be the number of vibrations in a minute to produce a note of the given pitch; dividing this by 60 will give 534 vibrations in the second. The syren is made self-revolving by the action of the air currents themselves; the holes, *m*, in the lower disc of the chamber instead of being pierced vertically are made to pass in an oblique direction through the plate, and the perforations, *n*, in the upper disc are also obliquely made, but inclined in the opposite direction. The currents of air from the chamber do not issue therefore in a vertical direction, but in side currents; these, by impinging against the oblique perforations in the upper disc, drive it round much after the manner in which the wind acts upon the sails of a windmill. The revolving spindle, T, of the apparatus is connected by means of an endless screw with wheelwork which registers the number of revolutions made in a given time. When the rapidity of vibration of any note has been determined, the length of the corresponding sonorous wave of that note may be found. The vibrations of a tuning-fork (fig. 1, Plate XIV.) are propagated through air at 0° C. a distance of 1093 feet in a second, and in a room where the temperature is generally about 27° C. 1120 feet in a second. This distance will therefore include 534 vibrations. Dividing 1120 by 534, the length of the sound-wave will be 2·097 feet, or about 2 feet 1 inch.

The expression *sonorous wave* means a condensation and its corresponding rarefaction, and a *vibration* an excursion of the vibrating body to and fro. In England and Germany the vibration of a sonorous wave is the full amplitude to and fro; the French vibration is only one-half, or an excursion one way, either to or fro. The time that each sonorous wave requires to pass over a particle of air is the time the particle requires to accomplish a complete vibration; and the time required by each particle to perform a complete oscillation is that required by the sonorous wave *to move through a distance equal to its own length.*

As the length of the wave vibrating 534 times in a second, with a velocity of transmission of sound in air at 27° C., was about 2 feet, then one will travel its own length in air in 1-534th of a second, which is the time required by each air particle it passes to complete an oscillation.

The length of the waves generated by a man's voice in ordinary conversation ranges from 8 to 12 feet, and in a woman's voice varies from 2 to 4 feet in length. The pitch of a woman's voice in the lower tone is therefore more than an octave above a man's, and in the higher tone it is two octaves.

The power of the ear for appreciating sound is restricted, and different observers have different capacities for its reception. The *minimum* limit for the normal ear is found to lie between 16 and 24 single vibrations in a second, and the *maximum* limit to reach 41,000. With many persons the power of hearing sound is determined at 16,000, or even 12,000 vibrations a second.

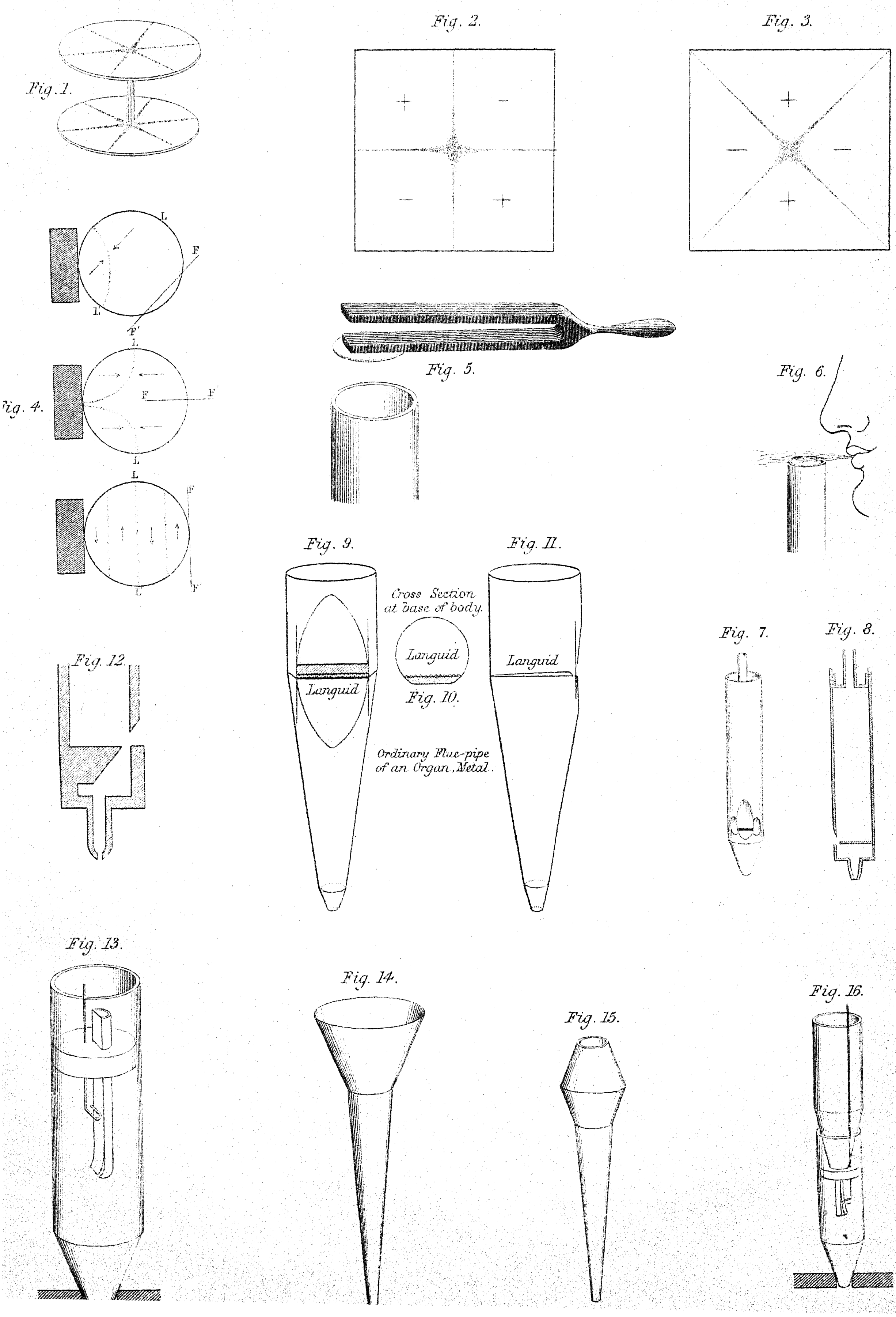


Fig. 1.
Fig. 2.
Fig. 3.
L
F
L'
F'
L
F
F'
L
Fig. 4.
L
F
F'
L
Fig. 5.
Fig. 6.
Fig. 9.
Fig. 11.
Cross Section
at base of body.
Languid
Languid
Languid
Fig. 10.
Ordinary Flue-pipe
of an Organ, Metal.
Fig. 7.
Fig. 8.
Fig. 12.
Fig. 13.
Fig. 14.
Fig. 15.
Fig. 16.

When a musical note is produced by double the number of vibrations of its fundamental tone it is termed the *octave*, and by multiplying the vibrations of the octave by two *its* octave is obtained, and by a further multiplication in the same proportion a series of numbers are obtained representing a series of octaves. The practical range of agreeable *musical* sounds is comprised between 40 and 4000 vibrations a second; the deepest tone of orchestral instruments is the E of the double bass, with $41\frac{1}{4}$ vibrations. Modern pianos and organs generally range as far as C, with 33 vibrations; the more recent grand pianos reach A below, with $27\frac{1}{2}$ vibrations. In organs of the first magnitude a lower octave is introduced on the pedals, reaching to C, with $16\frac{1}{2}$ vibrations a second; but the musical character of these lower tones is more or less imperfect, being so close to the limit where the power of the ear ceases to unite the vibrations. The highest note in the piano is C, with 4224 vibrations; the highest note of the orchestra is the D of the piccolo flute, with 4752 vibrations. The entire range of the human ear is about eleven octaves, or 33,792 vibrations above the lowest fundamental C, vibrating $16\frac{1}{2}$ times in a second. Taking the lowest fundamental tone, C, of the organ as the limit of musical tone, the vibrations of the octave tones are as follows:—

			Per Ft.		Per Sec.
Fundamental tone, Pedal octave	Organ		C 32,	vibrating	$16\frac{1}{2}$
			C 16	"	33
Organ keyboard.	. . .	1st Octave, ...	C 8	"	66
		2nd "	C 4	"	132
	Piano keyboard.	3rd "	C 2	"	264
		4th "	C 1	"	528
		5th "			
		6th "	C 6 in.	"	1056
	. . .	. . . . . .	C 3 "	"	2112
		7th "	C $1\frac{1}{2}$ "	"	4224

In order to determine the exact number of vibrations which correspond to a sounding body, the two sounds must be brought into unison; and as the ear is mathematically liable to error, Duhamel, to arrive at absolute accuracy, has devised an apparatus in which the sounds record to the eye the number of vibrations made during a given time. It consists of a wood or metal cylinder fixed to a vertical axis, and turned by a handle. The lower section of the axis is formed into a screw working in a fixed nut, so that on turning the cylinder in one direction it is raised, and in the opposite direction the cylinder is lowered. The cylinder has a sheet of paper rolled round it, the surface of which has received a coating of adhesive lampblack. The sounding body, a steel rod, is attached firmly at one end, and carries at the other a fine point just in contact with the surface of the blackened paper round the cylinder. When the rod is set vibrating the point will trace a short line on the paper, the length of which is determined by the amplitude of the vibrations of the end of the rod; but if the handle is turned the point no longer traces a line, but a series of undulations containing as many waves as the point has made vibrations.

By comparing the curves made by the vibrating rod with those traced by the point of a tuning-fork giving a known number of vibrations in a second, say 600, the rate of vibration of the rod in a second may be determined, so that if in the same time the rod made 180 vibrations and the tuning-fork 196, as the tuning-fork makes one vibration in the $\frac{1}{600}$ part of a second, it therefore makes 196 in the $\frac{196}{600}$ of a second. But as the rod makes 180 vibrations, it will make one vibration in the $\frac{196}{600}$ of a second, and in the same time the rod makes $\frac{196}{600 \times 180}$ of a second, and therefore makes $\frac{600 \times 180}{196}$ or 551·02 vibrations per second.

The *tuning-fork* is an instrument yielding a constant sound, and is employed as a standard for tuning musical instruments. In form it consists of an elastic steel rod bent into two parallel arms. When one arm of the fork is struck against a hard substance the fork is set into a state of intense vibration, which it at once communicates to the air, and the result is a musical note. The vibrating arm, swiftly advancing, compresses the air immediately in front of it, and as rapidly recovering itself, leaves a partial vacuum behind; this process being repeated by every vibration of the arm, the condensations and rarefactions, as they are formed, propagate themselves in uniform succession through the air, each condensation with its attendant rarefaction constituting a *sonorous wave*. In water the length of a wave (fig. 2, Plate XIV.) is measured from crest to crest, A, C, E. In sound the *wave-length* is the distance between each *successive condensation*. The note of the tuning-fork is strengthened by placing the end of the fork upon a sounding-board or box adjusted to the special note of the fork. The standard tuning-fork in any country represents the concert pitch of all instruments.

For some years the pitch of the standard tuning-fork has been getting higher in most of the large theatres of Europe, chiefly with a view to bring in the highest vocal tones of prima donnas, and for the same reason the standard fork is not the same in London, Paris, Berlin, Vienna, &c. The late Sir M. Costa was responsible for the high standard of the present orchestral pitch in London, maintained by him chiefly to give increased effect to the voices of three or four singers. In the year 1885 the pitch adopted by the royal bands was lowered to that of the French standard, and doubtless in the course of a year or two the French normal pitch will become universal in Great Britain. As the question of uniform pitch is one of considerable importance both to composers and singers, a commission was appointed in 1859 to establish a uniform pitch for France; and the standard fork in France gives 437·5 double vibrations per second. This standard is compulsory on all musical establishments and musical instrument manufacturers in France. In England there is at present no standard, and the consequence is that the tuning-forks of different makers frequently vary a little from each other. Tuning-forks are usually made to sound either C major or A minor; the former are used for pianofortes and the latter for violins, &c.

A musical note is that produced from a continuous and uniform succession of vibration. Musical notes are of two kinds, *simple* and *compound*. The tone yielded by the tuning-fork is simple; the tone from a wide-stopped organ pipe, or from a flute, is nearly simple; the tone from a musical string is compound. All musical notes have three distinctive qualities—namely, *pitch*, *intensity*, and *timbre* or *tone colour*. The *pitch* of a musical note is determined by the number of vibrations of the body producing the sound in a second. The *intensity* of the note depends upon the extent of the vibrations, and is proportional to the square of the amplitude of the vibrations producing the note. The *timbre*, or *tone colour*, is that peculiar quality of tone which distinguishes a note sounded on one instrument from the same note sounded on another instrument; as, for example, the 2 foot C on a violin from that of a harp or piano, the tone of the flute from that of the piccolo, the tone of the hautbois from that of the clarionet, or the tone of the diapason from that of the violon or gamba in the organ. In each case they are all produced by the same number of vibrations per second, and they may all be of the same intensity of sound, yet each one of the notes will possess very distinct characteristics of tone or *timbre*.

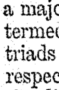
As all musical notes are dependent on their *pitch*, according to the velocity of the vibrations of the sounding body, there must be an interval between any two notes; and although any two or more notes sounded separately may each be musical, the effect may be the reverse when sounded together, and it will be found that unless the notes are *con-*

cordant the tones produced will be harsh and unpleasant to the ear. *Musical intervals* are therefore necessary to establish harmony; and when musical notes are compared one with another, it will be found that when the interval is as 2 : 1, or 4 : 1, or 2 : 4, &c., they so closely combine with one another, that for musical purposes they are considered as the same note. If C stands for a musical note produced by m vibrations, and c represents another musical note the result of two m vibrations, C and c are so similar as to be called in music by the same name, and the interval forms an *octave*, c being the octave *above* C, and C becomes the octave *below* c. If other musical notes are examined that are not octaves to each other, as any three notes X Y Z resulting from $x\,y\,z$ vibrations per second, these three notes will be concordant when sounded together, if the ratio of $x : y : z$ is as 4 : 5 : 6, and form what is termed a *harmonic triad*. These three notes of a harmonic triad, if sounded with a fourth note x, which is the octave of X, constitute in music a *major chord*. The notes of a chord may be extended one or more octaves; thus, C E G and c are a chord, and C c e g also form the same chord. When the ratio $z : y : x$ equals 10 : 12 : 15, the three tones are slightly dissonant. These three notes sounded together with the octave to the lower one constitute a *minor chord*.

The series of successive sounds which connect a note C with its octave c is termed the *diatonic* scale, or *gamut;* and the notes of the octave are called by the letters C, D, E, F, G, A, B, c; the scale is then continued by the octaves of these notes, c, d, e, f, g, a, b, c', and so on. These notes have also the relative names, *do* or *ut*, *re*, *mi*, *fa*, *sol*, *la*, *si*, *do*, as explained in Music, Chap. I., p. 175. The relations between the notes of the diatonic scale are:—C E G form a major triad, G B d form a major triad, and F A c form a major triad. These notes, C, G, and F, have therefore been termed the *tonic*, *dominant*, and *sub-dominant*, and the three triads the *tonic*, *dominant*, and *sub-dominant triads* or *chords* respectively. The numerical relation between the notes of the diatonic scale are therefore in the three proportions:—

$$C : E : G \; : : 4 : 5 : 6.$$
$$G : B : 2D : : 4 : 5 : 6.$$
$$F : A : 2C : : 4 : 5 : 6.$$

When the number of vibrations of the two sounds are as 3 to 2, the one which vibrates three times while the other vibrates two is called a *fifth* above the other; because in the diatonic scale of notes the vibrations of C and G are in this proportion, and G is the *fifth* sound reckoned from C. If the ratio of the vibrations be that of 3 to 4—that is, if the higher note make four vibrations while the lower note makes three, which is the case with C and its *fourth* F; or that of 4 to 5, which takes place with C and its *third* E; the combined effect of the two tones is agreeable. The same may be said of C and its *sixth* A, in which the ratio is that of 3 to 5; or of E and its *minor sixth* c', in which the ratio is that of 5 to 8; or of E and its *minor third* G, in which the ratio is that of 5 to 6. The diatonic musical scale in the treble clef is appended, with the denominations of the notes, and the fraction of a vibration which is completed while the first C completes one vibration, which fraction is greater than unity, or m, as the notes are rising. Thus while C vibrates once, D vibrates once and one-eighth, or eight vibrations of C take place during nine of those of D.



do	re	mi	fa	sol	la	si	do.
C	D	E	F	G	A	B	c, &c.
m	$\frac{9}{8}m$	$\frac{5}{4}m$	$\frac{4}{3}m$	$\frac{3}{2}m$	$\frac{5}{3}m$	$\frac{15}{8}m$	$2m$,&c.

The intervals between the successive notes being respectively—

C to D	D to E	E to F	F to G	G to A	A to B	B to c,
$\frac{9}{8}$	$\frac{10}{9}$	$\frac{16}{15}$	$\frac{9}{8}$	$\frac{10}{9}$	$\frac{9}{8}$	$\frac{16}{15}$

the three intervals are therefore $\frac{9}{8}$, $\frac{10}{9}$, and $\frac{16}{15}$; the two former constitute a *tone*, and the last a *semitone*, because the interval is about one-half the interval of a tone. The two tones will be found to differ by an interval of $\frac{81}{80}$, which is termed a *comma*. It is quite easy to distinguish by a correct ear this difference by a *comma* in two notes. In the major scale the interval from C to E equals $\frac{5}{4}$, while in the minor the ratio is $\frac{6}{5}$. The former constitutes a *major third*, the latter a *minor third*. The major third therefore exceeds the minor third by an interval of $\frac{25}{24}$. This interval is likewise called a semitone, though different from the interval of the semitone. The above harmonies are called *concords*; the others, though frequently very effective in music, are called *discords*. Thus, if F and G be sounded together, in which case F makes $\frac{4}{3}$ of a vibration while G makes $\frac{3}{2}$, or F makes 8 vibrations while G makes 9, the effect is unpleasant if continued for any length of time. On the pianoforte, in which the sound subsides quickly, this disagreeable effect is not so apparent; but on the organ, in which the sounds are sustained, the effect is most unpleasant, producing what are termed *beats*. The order of succession of the vibration of the principal harmonic intervals on the ear is given in fig. 3, Plate XIV.

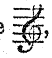
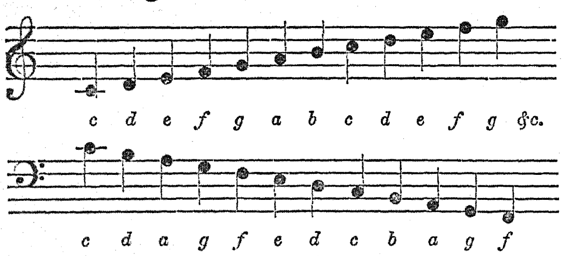
The *semitone* is not represented by a constant interval, being in one case equivalent to $\frac{16}{15}$, and in another to $\frac{25}{24}$. For the purposes of music notes are introduced intermediate to the seven notes of the diatonic scale; this is accomplished by raising or lowering these notes by an interval of $\frac{25}{24}$. When a note C is increased by this interval, it is said to be *sharpened*, and is denoted by the symbol C♯, called C *sharp;* that is, $C\sharp \div C = \frac{25}{24}$. When the note is lowered by the same interval, it is said to be flattened, and is represented by the ♭; thus B♭ is called B *flat;* that is, $B \div B\flat = \frac{25}{24}$. It will thus be found that the number of notes in the diatonic scale from C to c has been increased from seven to twenty-one, all of which can be readily distinguished by the ear; so that commencing from C as 1, the *chromatic scale* will be

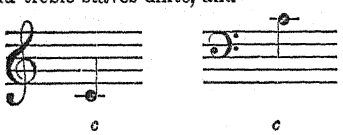
C	C♯	D♭	D	D♯	E♭	E
1	$\frac{25}{24}$	$\frac{27}{25}$	$\frac{9}{8}$	$\frac{75}{64}$	$\frac{6}{5}$	$\frac{5}{4}$

and so on. Hitherto C has been taken for the tonic or *key-note;* but any other of the twenty-one distinct notes of the above may be constituted the key-note, and a scale of notes constructed with regard to its octave. Some of these notes will be found to be the same as those in the scale of C, but others will be introduced to complete the necessary interval. This holds good for both the minor scale as well as the major scale, and all scales constructed by means of the fundamental triads.

The number of notes in the scale thus formed is found too great for convenience in playing on keyed instruments with fixed notes, such as the organ, the pianoforte, the Wheatstone concertina, &c., and they have therefore been reduced to twelve in the whole octave, or eleven between C and c. To effect this a compromise is made by tempering the notes slightly, so as to produce a scale in which a slight dissonance exists. The notes thus altered to form the scale constitute what is termed *equal temperament*, each interval being the twelfth root of 2, or 1·05946. The interval between the semitones is therefore expunged, and instead of two notes for C♯ and D♭, they become the same note, and so with the other semitonal intervals. Upon this principle the chromatic scale is formed, but with the result that the major triads are slightly dissonant. In the diatonic scale, if C represent 1, E is the equivalent of 1·25000, and G of 1·5000. By equal temperament, if C is 1, then E is denoted by 1·25992, and G

by 1·49831. The system of equal temperament enables all the various keys to be used on the organ or pianoforte, but as a consequence no key is absolutely in tune; while, on the contrary, if the instruments are tuned in *unequal temperament*, only certain keys can be utilized, the others being too dissonant to be employed. It is only of late years that organs have been universally tuned upon equal temperament. As musical education is mostly based on pianoforte and organ instruction, singers and instrumentalists usually adopt equally-tempered intervals; but in the case of vocal quartets and string quartets, who sing and play without instrumental accompaniment, the pure temperaments usually are adopted as producing the purest musical tone and effect.

As it would be impossible to write music by giving the notes as represented by their number of vibrations, the notation system is universally employed. Taking the tone of the 8-feet pipe of the organ, C, the octave of notes is expressed by capital letters, C, D, E, F, G, A, B; the next octave by corresponding smaller letters, *c, d, e, f, g, a, b;* and the several octaves higher by the indices placed over the letters, as $c', d', e', f', g', a', b'$; c'', d'', &c. The octaves below the 8-feet C are expressed as $c_{,}$, $c_{,,}$, &c. The series of octaves on the pianoforte will therefore be expressed by $c_{,,}, c_{,}, c, c', c'', c''', c''''$. In writing music the letters give place to signs which indicate the length of time a note is to be sustained or prolonged in playing or singing. These signs are written upon a series of five lines called a stave: the treble stave is indicated by the signature , the bass by , thus

When the five lines are insufficient, they are continued above and below the respective staves, and are called *ledger* lines. The bass and treble staves unite, and



represent the same note, which is the middle *c;* the standard *c'* is the *c* upon the third space in the treble stave.

ARITHMETIC.—CHAPTER VII.

ADDITION AND SUBTRACTION OF COMMON FRACTIONS.

If the principles laid down in the last chapter be well understood, the operations concerned in the arithmetic of common fractions will present little difficulty. Those principles are, however, in themselves of little practical value. They derive their utility chiefly from the applications of them which we are about to consider; namely, the addition, subtraction, multiplication, and division of fractions.

Addition of Fractions.

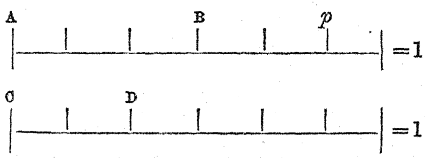
Suppose we have this question—What is the sum of two fifths and one fifth? The sort of units to be added are precisely the same: they are fifths, and their number is two and one; that is, three. The answer to the question is therefore three fifths. Now the question and its answer, written in symbols are

$$\frac{2}{5}+\frac{1}{5}=\frac{2+1}{5}=\frac{3}{5}.$$

That is, *the sum of two fractions having a common denominator is found by taking the sum of the numerators, and writing under it the common denominator.*

But fractions having any denominators may be reduced to others having the same or a common denominator; consequently, any two fractions may be added together by attending to a few simple practical rules.

We may be asked, for instance, what is the sum of $\frac{1}{2}+\frac{1}{3}$? Here the fractions express different divisions of the primitive unit, as exemplified in the following diagram. By it we see that $\frac{1}{2}$ is the expression for A B, and $\frac{1}{3}$ for C D;



Now A B is equivalent to three sixths, and C D to two sixths; hence three sixths + two sixths are equivalent to five sixths $= A\,p$. The whole of this process, written in figurate symbols, is

$$\frac{1}{2}+\frac{1}{3}=\frac{3}{6}+\frac{2}{6}=\frac{3+2}{6}=\frac{5}{6}.$$

We may apply the same kind of reasoning to other cases, as

$$\frac{1}{2}+\frac{2}{7}=\frac{11}{14} \qquad \frac{3}{4}+\frac{1}{12}=\frac{5}{6} \qquad \frac{2}{3}+\frac{1}{5}=\frac{13}{15}$$

$$\frac{1}{2}+\frac{5}{6}=1\frac{1}{3} \qquad \frac{7}{12}+\frac{1}{6}=\frac{3}{4} \qquad \frac{8}{7}+\frac{9}{11}=1\frac{74}{77}$$

If the fractions $\frac{2}{3}$ and $\frac{3}{4}$ are to be added we multiply the fraction $\frac{2}{3}$ by 4 (the denominator of the latter fraction), which yields $\frac{8}{12}$, and the fraction $\frac{3}{4}$ by 3 (the denominator of the former fraction), which yields $\frac{9}{12}$; we have then $\frac{8}{12}$ to add to $\frac{9}{12}$, and the answer is $\frac{17}{12}$ or $1\frac{5}{12}$.

If it is required to find the sum of three or more fractions the method of operation is strictly the same.

$$\text{Thus, }\frac{1}{2}+\frac{1}{3}+\frac{1}{4}=\frac{6}{12}+\frac{4}{12}+\frac{3}{12}=\frac{6+4+3}{12}=\frac{13}{12}=1\frac{1}{12}$$

$$\frac{1}{2}+\frac{2}{3}+\frac{3}{4}=1\frac{11}{12} \qquad \frac{1}{2}+\frac{1}{4}+\frac{1}{12}=\frac{5}{6}$$

$$\frac{1}{2}+\frac{3}{4}+\frac{4}{5}=2\frac{1}{20} \qquad \frac{7}{12}+\frac{1}{4}+\frac{1}{5}=1\frac{1}{30}$$

Mixed Numbers.—It frequently happens that fractions accompany integers. In cases of this kind we may operate (1) upon the whole numbers and (2) on the fractions separately. Take as an example the following:—

What is the sum of $3\frac{2}{5}+2\frac{3}{4}$? The sum $3+2$ is 5, and the sum $\frac{2}{5}+\frac{3}{4}$ is $\frac{23}{20}=1\frac{3}{20}$: then $5+1\frac{3}{20}=6\frac{3}{20}$ is the answer sought. We might, therefore, have at once written out the process thus—

$$3\frac{2}{5}+2\frac{3}{4}=3+2+\frac{8}{20}+\frac{15}{20}=5+1\frac{3}{20}=6\frac{3}{20}$$

This is most commonly the easiest mode of proceeding; but we may, should we think proper, reduce the mixed numbers to improper fractions, and proceed to add the results.

$$\text{Thus, }3\frac{2}{5}+2\frac{3}{4}=\frac{17}{5}+\frac{11}{4}=\frac{68+55}{20}=\frac{123}{20}=\textit{Ans. }6\frac{3}{20}$$

Similarly,

$$1\frac{4}{5}+1\frac{5}{8}=1+1+\frac{32}{40}+\frac{25}{40}=2+\frac{32+25}{40}=\textit{Ans. }3\frac{17}{40}$$

$$\text{or, } 1\frac{4}{5} + 1\frac{5}{8} = \frac{9}{5} + \frac{13}{8} = \frac{72}{40} + \frac{65}{40} = \frac{137}{40} = \textit{Ans. } 3\frac{17}{40}$$

Again,

$$1\frac{1}{2} + 2\frac{1}{3} + 3\frac{1}{4} = 1\frac{6}{12} + 2\frac{4}{12} + 3\frac{3}{12} = 6\frac{13}{12} = \textit{Ans. } 7\frac{1}{12}$$

$$3\frac{1}{2} + 4\frac{3}{4} = \textit{Ans. } 8\frac{1}{4}. \qquad 11\frac{3}{4} + 4\frac{2}{3} = \textit{Ans. } 16\frac{5}{12}$$

$$\frac{47}{4} + 4 + \frac{2}{3} + \frac{17}{6} + \frac{7}{12} + 3\frac{1}{2} = \textit{Ans. } 23\frac{1}{3}$$

Subtraction of Fractions.

Subtraction is a mode of comparing quantities which are of the same kind. Fractions of the same species of unit, when made to have a common denominator, are greater or less than each other according as their numerators are greater or less. Thus, $\frac{8}{9}$ is greater than $\frac{7}{9}$ by $\frac{1}{9}$, because both are obtained by dividing 1 into 9 equal parts, and of these parts the first has 8, whereas the second has only 7.

$$\text{Therefore } \frac{8}{9} - \frac{7}{9} = \frac{8-7}{9} = \frac{1}{9}$$

This, we see, is the answer to each of such questions as these:—How much does $\frac{8}{9}$ exceed $\frac{7}{9}$? How much is $\frac{7}{9}$ less than $\frac{8}{9}$? If $\frac{7}{9}$ be subtracted from $\frac{8}{9}$ what quantity remains? And so on. The method of subtracting one fraction from another is very simple when they have both the same denominator; and it is only when they are placed in that condition that subtraction can really be effected. Taking the same fractions as we have used above, $\frac{3}{4} - \frac{2}{3}$, we proceed in the same way as before to reduce them to a common denominator, $\frac{9}{12} - \frac{8}{12} = \frac{1}{12}$. The rule for working subtraction of fractions may be expressed in full as follows:—

Reduce the fractions to a common denominator (if their given denominators be different); then take the difference of the numerators and place under it the common denominator; the new fraction thus formed is the remainder sought.

As examples of the application of this rule it may be asked, what is the difference

$$\text{between } \frac{1}{2} \text{ and } \frac{1}{3}?\ \frac{1}{2} - \frac{1}{3} = \frac{3}{6} - \frac{2}{6} = \frac{1}{6}$$

$$\text{"}\ \frac{3}{4} \text{ and } \frac{2}{3}?\ \frac{3}{4} - \frac{2}{3} = \frac{9}{12} - \frac{8}{12} = \frac{1}{12}$$

$$\text{"}\ \frac{6}{7} \text{ and } \frac{4}{5}?\ \frac{6}{7} - \frac{4}{5} = \frac{30}{35} - \frac{28}{35} = \frac{2}{35}$$

$$\text{"}\ \frac{8}{9} \text{ and } \frac{7}{8}?\ \frac{8}{9} - \frac{7}{8} = \frac{64}{72} - \frac{63}{72} = \frac{1}{72}$$

Mixed Numbers.—When whole numbers and fractions are conjoined, they may be operated upon either separately or by reducing them to improper fractions. It will be found in practice that the former mode is the readiest in *addition*, the latter the most convenient in *subtraction*.

$$\text{Thus, } 2\frac{1}{2} - 1\frac{2}{3} = \frac{5}{2} - \frac{5}{3} = \frac{15-10}{6} = \frac{5}{6}$$

If we proceed, in this instance, to reduce the $\frac{1}{2}$ and $\frac{2}{3}$ to a common denominator, we arrive at a subtraction $2\frac{3}{6} - 1\frac{4}{6}$, which is an impossible operation as respects the fractions. This, however, may be remedied by taking a unit of the 2 and writing it $\frac{6}{6}$; adding this to the $\frac{3}{6}$ we get $\frac{9}{6}$ which makes our expression possible in all its parts; it is then transformed into

$$1\frac{9}{6} - 1\frac{4}{6} = \frac{5}{6}, \text{ as before.}$$

This sort of difficulty will occur in practice as often as not; it is therefore advisable in the meantime to adopt the former mode in preference. The following examples may be verified:—

$$3\frac{1}{5} - 2\frac{7}{8} = \frac{16}{5} - \frac{23}{8} = \frac{128-115}{40} = \frac{13}{40};$$

$$13\frac{1}{2} - 7\frac{3}{4} = 5\frac{3}{4}; \quad 12\frac{3}{4} - 10\frac{13}{16} = 1\frac{15}{16}.$$

The following are cases which very frequently occur in practice. The readiest mode of proceeding is this: find (1) the sum of all the *additive* terms, and (2) the sum of all the *subtractive*, then (3) find the difference of the results. For example—

What is $\frac{1}{2} - \frac{1}{3} + \frac{1}{4} - \frac{1}{5} + \frac{1}{6}$? Here the two sorts of quantities are—

$$\textit{Additive, } \frac{1}{2} + \frac{1}{4} + \frac{1}{6} = \frac{6}{12} + \frac{3}{12} + \frac{2}{12} = \frac{11}{12}$$

$$\textit{Subtractive, } \frac{1}{3} + \frac{1}{5} = \frac{5}{15} + \frac{3}{15} = \frac{8}{15}$$

$$\text{Then, } \frac{11}{12} - \frac{8}{15} = \frac{55}{60} - \frac{32}{60} = \frac{23}{60}$$

$$\text{Similarly, } \frac{1}{2} + \frac{1}{3} + \frac{1}{6} - \frac{1}{8} - \frac{1}{4} = \frac{5}{8};$$

$$2 - \frac{1}{7} + \frac{12}{13} = 2\frac{71}{91}; \quad 11\frac{2}{3} + 8\frac{7}{9} - 9\frac{19}{22} = 10\frac{115}{198};$$

$$1 - \frac{1}{2} + \frac{2}{3} + \frac{3}{4} + \frac{4}{5} + \frac{5}{6} = 3\frac{11}{20}.$$

EXERCISES.

In Addition of Fractions.—(1) $\frac{4}{7} + \frac{1}{3} = \frac{12}{21} + \frac{7}{21} =$ *Ans.* $\frac{19}{21}$. (2) $\frac{2}{5} + \frac{3}{4} =$ *Ans.* $1\frac{3}{20}$. (3) $\frac{4}{9} + \frac{5}{8} + \frac{11}{12} =$ *Ans.* $1\frac{71}{72}$. (4) $\frac{2}{3} + \frac{3}{5} + \frac{7}{11} =$ *Ans.* $1\frac{149}{165}$. Add (1) $\frac{3}{4}$, $\frac{2}{5}$, and $\frac{2}{7}$. *Ans.* $1\frac{61}{140}$. (2) $\frac{2}{5}$, $\frac{3}{7}$, and $\frac{5}{8}$. *Ans.* $1\frac{127}{280}$. (3) $\frac{5}{6}$, $\frac{7}{15}$, and $\frac{17}{24}$. *Ans.* $2\frac{1}{120}$. (4) $\frac{5}{12}$, $\frac{3}{10}$, $1\frac{1}{7}$. *Ans.* $1\frac{361}{420}$. (5) $\frac{2}{27}$, $\frac{7}{54}$, $1\frac{2}{5}$. *Ans.* $1\frac{163}{270}$. (6) $\frac{5}{8} + \frac{2}{3}$ of $2\frac{3}{4}$ $\left(= \frac{2}{3} \text{ of } \frac{11}{4}\right)$. *Ans.* $2\frac{11}{24}$. (7) $\frac{2}{15} + \frac{1}{6} + \frac{1}{10}$. *Ans.* $\frac{2}{5}$.

In Subtraction of Fractions.—(1) $\frac{11}{13} - \frac{5}{13} = \frac{6}{13}$; (2) $\frac{13}{18} - \frac{5}{18} = \frac{4}{9}$; (3) $3\frac{2}{3} - 1\frac{1}{2} = 2\frac{1}{6}$; (4) $\frac{4}{5} - \frac{5}{7} = \frac{3}{35}$; (5) $\frac{1}{2}$ of $\frac{3}{7}$ $\left(= \frac{3}{14}\right) - \frac{2}{15}$. *Ans.* $\frac{17}{210}$. (6) $\frac{14}{15} - \frac{21}{55}$. *Ans.* $\frac{91}{165}$. (7) $\frac{3}{4}$ of $5 - \frac{2}{3}$ of 4 $\left(= \frac{3}{4} \text{ of } \frac{5}{1} - \frac{2}{3} \text{ of } \frac{4}{1}\right)$. *Ans.* $1\frac{1}{12}$. (8) $\frac{11}{12} - \frac{4}{7}$. *Ans.* $\frac{29}{84}$. (9) $5\frac{7}{3} - 6\frac{3}{4} + 1\frac{5}{6} =$ *Ans.* $2\frac{5}{12}$. (10) $8\frac{1}{2} + 5\frac{11}{12} + \frac{3}{8} - \frac{15}{3} + \frac{7}{24} + 3\frac{5}{9} = 14\frac{19}{24} - 8\frac{61}{72} =$ *Ans.* $5\frac{17}{18}$.

THE LATIN LANGUAGE.—CHAPTER VIII.

SYNOPSIS OF CONJUGATION—DEPONENT, IMPERSONAL, NEUTER-PASSIVE, AND DEFECTIVE VERBS—EXERCISES.

THERE are still a few things to be told concerning Latin verbs. It is not intended that all that is here stated should be verbally, as it stands, committed to memory. Grammar is a register of facts, arranged in such an order as shall enable them to be easily understood, readily referred to, and immediately applied. A large number of small, minute, precise points, which have required great diligence to gather together, assort, and record, may not come within the experience or the need of all students, but, that they may be at the service of those who do need to know them, they must be set down as near as may be to the matter with which they have the closest relation. The regular verbs have been pretty fully and very carefully explained. The irregular verbs have also, so far as was possible within our space, been treated in detail. But there are two supplementary matters to which we are anxious to invite the student before passing away from the consideration of the verb as an individual element in speech. The one is to bring together the whole of the inflexional terminations which require to be added by agglutination to, and brought into cohesive union with, the organic crude forms or roots which constitute the staple significant element in verbs—so that their likeness and kinship may be seen, and therefore their similarity of meaning known. The other is to complete what requires to be registered regarding irregular verbs, in so far as these irregularities are of such a special and peculiar sort as to be unlikely to be understood by the student, unless distinctly brought before him in some clearly arranged form, or likely, when met with, if unmentioned and unrecorded, to strike his mind as difficulties and hinder his progress. This latter design involves some explanation of deponent, impersonal, neuter-passive, and defective verbs. In fulfilment of the first of these designs, we present a synoptical view, in the table on the next page, of the terminal affixes of all the four conjugations.

If the terminations given in the table be affixed to the root of the usual four principal parts of any verb, the entire verb may, by their help, be easily formed throughout.

It will be noticed also on examining the table (1) that the tenses formed from *i* are alike in all the four conjugations; (2) that the passive voice is formed from the active by adding *r* to *o*, and changing *m* into *r* in the tenses formed from *o* and *re;* and (3) that the perfect tenses in the passive are made up of the perfect participle and the parts of *sum.*

The verbal roots, as the student knows, may end either (1) in a vowel, or (2) in a consonant; as *ama-* of *amo*, *doce-* of *doceo*, *audi-* of *audio*, *ru-* of *ruo*, *leg-* of *lego.*

When the root ends in *a*, *e*, or *i*, these vowels coalesce with the short vowel of the termination, and really form contracted verbs; as

Ama-o,	ama-ĭs,	ama-ĭt,	ama-ĭmus,	ama-ĭtis,	ama-unt,
Amō,	amās,	amăt,	amāmus,	amātis,	amant,
Doce-o,	doce-ĭs	doce-ĭt,	doce-ĭmus,	doce-ĭtis,	doce-unt,
Doceo,	docēs,	docĕt,	docēmus,	docētis,	docent,
Audi-o,	audi-ĭs,	audi-ĭt,	audi-ĭmus,	audi-ĭtis,	audiunt,
Audio,	audīs,	audĭt,	audīmus,	audītis,	audiunt,

and so on with the other tenses from *o* and *re;* whereas when it ends in a consonant or *u*, the verb takes the form of the Third Conjugation; as

Leg-o,	leg-ĭs,	leg-ĭt,	leg-ĭmus,	leg-ĭtis,	leg-unt.
Ru-o,	ru-ĭs,	ru-ĭt,	ru-ĭmus,	ru-ĭtis,	ru-unt.

This seems to show that there was originally in reality only one conjugation, the Third, and that the others—viz. the First, Second, and Fourth—are contracted forms of that one.

When this abstract of the fourfold paradigm of conjugation has been carefully examined, it occurs to one at once that the First, Second, and Fourth Conjugations are much more nearly alike in form than either of them is to the Third. On searching for a reason, we find that the three vowels *a*, *e*, *i* are the characteristics of these three conjugations which most resemble each other, though in the case of the First Conjugation the characteristic *a* has been in several inflexions absorbed into the final *o* or other affix beginning with a vowel. In the Third Conjugation, however, the final *o* is in general preceded by a consonant, and as there is no vowel to work upon to secure euphonic pleasantness in making the inflecting changes, the consonant requires to be changed, and hence the greater complexity of the Third than of the other conjugations, which, by the aid of their characteristic vowels, have been enabled to keep their crude root-form intact throughout. If, then, we regard the changes occurring in inflexion as made for euphonic purposes, we shall all the more readily perceive the strong points of resemblance which make it likely that all Latin verbs are really conjugated on the same type, and may be the better understood the more clearly we see this unity of form in diversity of appearance.

EXERCISES IN THE FORMAL CONJUGATION OF VERBS.

I. Draw out tabular forms similar to those given below, and (1) from the lists hereafter supplied, and (2) from those of verbs more or less irregular in their perfects and supines (p. 517), fill up these forms in the way shown.

(*a*) Active (First Conjugation).

	Indic.	Imp.	Subj.	Infin.	Partic.
Present	Amo	Ama	Amem	Amare	Amans
Imperf.	Amabam		Amarem		
Perf.	Amavi		Amaverim	Amavisse	
Pluper.	Amaveram		Amavissem		
Future	Amabo			Amaturus esse	Amaturus
F.-Per.	Amavero				
	Gerunds, Amand-i, -o -um.			Supines, Amat-um, -u.	

Voc-o, -avi, -atum, *I call.*	Æstim-o, -avi, -atum, *I value.*
Proper-o, -avi, -atum, *I hasten.*	Mut-o -avi, -atum, *I change.*

(*b*) Passive (First Conjugation).

	Indic.	Imp.	Subj.	Infin.	Partic.
Pres.	Amor	Amare	Amer	Amari	
Imp.	Amabar		Amarer		
Perf.	Amatus sum *or* fui		Amatus sim *or* fuerim	Amatus esse *or* fuisse	Amatus
Plup.	Amatus eram *or* fueram		Amatus essem *or* fuissem		
Fut.	Amabor			Amatum iri	Amandus
F.-P	Amatus ero				

Mut-or, -atus, -ari, *I am changed.*	Plac-or, -atus, -ari, *I am appeas'd*
Am-or, -atus, -ari, *I am loved.*	Vac-or, -atus, -ari, *I am called.*

II. Repeat in similar forms (1) tables of the undergiven verbs in the Second, Third, and Fourth Conjugations, and (2) tables of six verbs from the lists on page 517, &c., belonging to the three conjugations.

Doc-eo, -ui, -tum, *I teach.*	Hab-eo, -ui, -itum, *I have.*
Ten-eo, -ui, -tum, *I hold.*	Jac-eo, -ui, -itum, *I lie.*
Lego, lexi, lectum, *I read.*	Vinco, vici, victum, *I conquer.*
Scribo, scripsi, scriptum, *I write.*	Ago, egi, actum, *I drive.*
Pun-io, -ivi, -itum, *I punish.*	Dorm-io, -ivi, -itum, *I sleep.*
Fin-io, -ivi, -itum, *I finish.*	Nutr-io, -ivi, -itum, *I nourish.*

III. Draw up in the following form a table, and fill in, as shown, all the verbs contained in the sentences given under this parsing table:—

Latin.	English.	Kind.	Voice.	Mood.	Tense.	Num.	Pers.
Regitis	*Ye are ruling*	Trans.	Act.	Ind.	Pres.	Plu.	2nd
Latus esset	*He would have been borne*	Irreg.	Pass.	Sub.	Plup.	Sing.	3rd
Mirabitur	*He will admire*	Dep.	Act.	Ind.	Fut.	Sing.	3rd

Vocaris. Amaretur. Portatus sum. Rogandus. Servabimini. Æstimare. Mutemur. Ornari. Vocaremur. Amati simus. Portabamini. Rogatum iri. Vocati sunt. Æstimatus fueram. Vocatus. Pater amabatur. Illi mutantur. Fratres æstimabuntur. Poetæ ornatur. Pueri poterint. Cæsar poterat. Cæsar servatus est. Rex bonus amatur. Nos vocaremur. Portandus. Forma laudetur. Vos mutabimini. Illi laudantur. Libri boni servati erunt. Rex placatus est. Regina placata est. Regnum servatum est. Equus ibit. Cives

ACTIVE VOICE.

Indicative Mood.

	Stem	*Singular.* 1.	2.	3.	*Plural.* 1.	2.	3.
Present.	Am-	ō,	ās,	ăt,	āmŭs,	ātĭs,	ant.
	Mŏn-	ĕō,	ēs,	ĕt,	ēmŭs,	ētĭs,	ent.
	Rĕg-	ō,	ĭs,	ĭt,	ĭmŭs,	ĭtĭs,	unt.
	Aud-	ĭō,	īs,	ĭt,	īmŭs,	ītĭs,	ĭunt.
Imperfect.	Amā-, Mŏnē-, Rĕg-ē-, Audĭ-ē-	bam,	bās,	băt,	bāmŭs,	bātĭs,	bant.
Perfect.	Amāv-, Mŏnŭ-, Rex-, Audīv-	ī	istī,	ĭt,	ĭmŭs,	istĭs,	ērunt *or* ērĕ.
Pluperfect.	Amāv-, Mŏnŭ-, Rex-, Audīv-	ĕram,	ĕrās,	ĕrăt,	ĕrāmŭs,	ĕrātĭs,	ĕrant.
Fut. Simple.	Amā-, Mŏnē	bō,	bĭs,	bĭt,	bĭmŭs,	bĭtĭs,	bunt.
	Rĕg-, Audĭ-	am,	ēs,	ĕt,	ēmŭs,	ētĭs,	ent.
Fut. Perf.	Amāv-, Mŏnŭ-, Rex-, Audīv-	ĕrō,	ĕris,	ĕrĭt,	ĕrimŭs,	ĕritĭs,	ĕrint.

Subjunctive Mood.

	Stem	*Singular.* 1.	2.	3.	*Plural.* 1.	2.	3.
Present.	Am-	em,	ēs,	ĕt,	ēmŭs,	ētĭs,	ent.
	Mŏn-	ĕam,	ĕās,	ĕăt,	ĕāmŭs,	ĕātĭs,	ĕant.
	Rĕg-	am,	ās,	ăt,	āmŭs,	ātĭs,	ant.
	Aud-	ĭam,	ĭās,	ĭăt,	ĭāmŭs,	ĭātĭs,	ĭant.
Imperfect.	Amā-, Mŏnē-, Rĕgĕ-, Audī-	rem,	rēs,	rĕt,	rēmŭs,	rētĭs,	rent.
Perfect.	Amāv-, Mŏnŭ-, Rex-, Audīv-	ĕrim,	ĕris,	ĕrĭt,	ĕrimŭs,	ĕritĭs,	ĕrint.
Pluperfect.	Amāv-, Mŏnŭ-, Rex-, Audīv-	issem,	issēs,	issĕt,	issēmŭs,	issētĭs,	issent.

Imperative Mood.

	Present. *S.* 2.	*P.* 2.	Future. *S.* 2.	*S.* 3.	*P.* 2.	*P.* 3.
Am-	ā,	ātĕ.	ātō,	ātō,	ātōtĕ,	antō.
Mŏn-	ē,	ētĕ.	ētō,	ētō,	ētōtĕ,	entō.
Rĕg-	ĕ,	ĭtĕ.	ĭtō,	ĭtō,	ĭtōtĕ,	untō.
Aud-	ī,	ītĕ.	ītō,	ītō,	ītōtĕ,	ĭunto.

Infinitive.

Pres. Imperf.		Perf. Pluperf.	
Amā-, Mŏnē-, Regĕ-, Audī-	rĕ	Amāv-, Mŏnŭ-, Rex-, Audīv-	issĕ.

Gerund.

	N. Ac.	G.	D. Abl.
Am-and-, Mŏn-end-, Rĕg-end-, Audī-end-	um,	ī,	ō.

Participle, Pres. Imp.

Am-	ans.
Mŏn-, Rĕg-, Audĭ-	ens.

Participle, Future.

Amāt-, Monĭt-, Rect-, Audīt-	ūrŭs.

Supines.

	1.	2.
Amāt-, Mŏnĭt-, Rĕct-, Audīt-	um,	ū.

PASSIVE VOICE.

Indicative Mood.

	Stem	*Singular.* 1.	2.	3.	*Plural.* 1.	2.	3.
Present.	Am-	ŏr,	āris,	ātŭr,	āmŭr,	āminī,	antŭr.
	Mŏn-	ĕŏr,	ēris,	ētŭr,	ēmŭr,	ēminī,	entŭr.
	Rĕg-	ŏr,	ĕris,	ĭtŭr,	ĭmŭr,	ĭminī,	untŭr.
	Aud-	ĭŏr,	īris,	ītŭr,	īmŭr,	īminī,	ĭuntŭr.
Imperfect.	Amā-, Mŏnē-, Rĕgē-, Audĭ-ē-	băr,	bārĭs, *or* bārĕ.	bātŭr,	bāmŭr,	bāmĭnī,	bantŭr.
Perfect.	Amāt-, Mŏnĭt-, Rect-, Audīt-	ŭs sum,	ŭs ĕs,	ŭs est,	ī sŭmŭs,	ī estĭs,	ī sunt.
Pluperfect.	Amāt-, Mŏnĭt-, Rect-, Audīt-	ŭs ĕram,	ŭs ĕrās,	ŭs ĕrăt,	ī ĕrāmŭs,	ī ĕrātĭs,	ī ĕrant.
Fut. Simple.	Amā-, Mŏnē-	bŏr,	bĕris, *or* bĕre,	bĭtŭr,	bĭmŭr,	bĭmĭnī,	buntŭr.
	Rĕg-, Audĭ-	ăr,	ēris, *or* ērĕ	ētŭr,	ēmŭr,	ēmĭnī,	entŭr.
Fut. Perf.	Amāt-, Mŏnĭt-, Rect-, Audīt-	ŭs ĕrō,	ŭs ĕrĭs,	ŭs ĕrĭt,	ī ĕrĭmŭs,	ī ĕritĭs,	ī ĕrunt.

Subjunctive Mood.

	Stem	*Singular.* 1.	2.	3.	*Plural.* 1.	2.	3.
Present.	Am-	ĕr,	ēris *or* ērĕ,	ētŭr,	ēmŭr,	ēminī,	entŭr.
	Mŏnĕ-, Rĕg-, Audĭ-	ăr,	āris *or* ārĕ,	ātŭr,	āmŭr,	āminī,	antŭr.
Imperfect.	Amā-, Mŏnē-, Rĕgĕ-, Audī-	rĕr,	rēris *or* rērĕ,	rētŭr,	rēmŭr,	rēminī,	rentŭr.
Perfect.	Amāt-, Mŏnĭt-, Rect-, Audīt-	ŭs sim,	ŭs sis,	ŭs sĭt,	ī simŭs,	ī sitĭs,	ī sint.
Pluperfect.	Amāt-, Mŏnĭt-, Rect-, Audīt-	ŭs essem,	ŭs essēs,	ŭs essĕt,	ī essēmŭs,	ī essētĭs,	ī essent.

Imperative Mood.

	Present. *S.* 2.	*P.* 2.	Future. *S.* 2.	*S.* 3.	*P.* 3.
Am-	ārĕ,	āmĭnī.	ātŏr,	ātŏr,	antŏr.
Mŏn-	ērĕ,	ēminī.	ētŏr,	ētŏr,	entŏr.
Rĕg-	ĕrĕ,	ĭmĭnī.	ĭtŏr,	ĭtŏr,	untŏr.
Aud-	īrĕ,	īmĭnī.	ītŏr,	ītŏr,	ĭuntŏr.

Infinitive.

Pres. Imperf.		Perf. Pluperf.		Future.	
Amā-, Mŏnē-	rī.	Amāt-, Mŏnĭt-, Rect-, Audīt-	ŭs essĕ.	Amāt-, Mŏnĭt-, Rect-, Audīt-	um īrī.
Rĕg-	ī.				
Audī-	rī.				

Participle, Perfect.

Amāt-, Mŏnĭt-, Rect-, Audīt-	ŭs.

Gerundive.

Amand-, Mŏnend-, Rĕgend-, Audĭend-	ŭs.

nolebant. Ivisse. Fiemus. Ferendo. Iturus. Nos fiamus. Estis. Ferte. Eundum. Tu ferreris. Opus factum est. Esse. Milites tulēre. Illæ factæ sint. Puer ivit. Edendo. Fieri. Posse. Ferens. Ferentis. Puella itura.

DEPONENT VERBS.

Grammarians are not always able to observe the precise laws of definition laid down by the logicians. As a precautionary rule nothing could be more wisely insisted on than that definitions should not be made by negations. Wherever it is possible we must prefer such definitions as inform us what things *are* rather than what they *are not*. We want to know the actual positive qualities of the things about which we reason. When, however, a distinct, clear, and positive idea has been made familiar to the mind, such as that of "backboned animals" (*vertebrata*), an express negation of that thoroughly understood idea can be easily realized, and we have no difficulty in taking into our minds the notion of express oppositeness, as of the *invertebrata*, or animals without a backbone. In defining—as we have done (pp. 319 and 418)—deponent verbs as verbs which *depone* or lay aside their active form, and through their passive form express ideas which are usually indicated by the form deponed, we have had to trust to the student's apprehension of this negative definition. He has been instructed that a given *form* implies a causative agency, and that another indicates a sufferance of or from such a causative agency, and hence it was necessary to explain the phenomenon in language—that certain verbs, though having the passive form, have an active signification. This is perhaps—when both forms are well known—most easily explained by saying that deponent verbs are defective in voice. This view of deponing accounts for the fact that some forms of deponent verbs, such as the perfect tenses and perfect participles, are sometimes used passively; as, *adepta libertate*, when liberty had been got at; *parum comitatus ex urbe exivit*, he went out of the city, accompanied only by few; *postquam majorem partem itineris emensam cernunt*, when they see the greater part of their journey has been measured out (viz. got through); *ementita auspicia*, forged oracles. And it also explains why several deponent verbs have even retained in use some of the personal tenses of their former active conjugation, especially the perfect tenses, as is the case with the following:—

Adulari,	*to fawn, flatter, cringe to.*	Ludificari,	*to make game of.*
Altercari,	*to wrangle.*	Medicari,	*to remedy.*
Amplecti *and* Amplexari,	*to encircle, embrace*	Mereri,	*to deserve.*
Assentiri,	*to assent to.*	Misereri,	*to have pity.*
Aucupari,	*to lie in wait for.*	Moderari,	*to regulate, moderate.*
Augurari,	*to interpret omens.*	Munerari,	*to make presents.*
Cachinnari,	*to laugh aloud.*	Opinari,	*to be of opinion.*
Comitari,	*to accompany.*	Opitulari,	*to bring help to.*
Contemplari,	*to observe carefully*	Pollueri,	*to promise.*
Depasci,	*to feed upon.*	Populari,	*to ravage.*
Expergisci,	*to awaken.*	Reciprocari,	*to push to and fro, reciprocate.*
Frustrari,	*to disappoint, frustrate.*	Reverti and (Wanting).	
Imitari,	*to imitate.*	Revertere,	*to return.*
Impertiri,	*to share with, impart.*	Ruminari,	*to chew the cud.*
Insidiari,	*to lie in wait for.*	Stipulari,	*to bargain, stipulate.*
Jurgari,	*to quarrel.*	Vagari,	*to go to and fro.*
Lacrymari,	*to weep.*	Venerari,	*to worship.*
Lætari,	*to rejoice.*	Vociferari,	*to cry aloud, vociferate.*

Owing to the difficulty and importance of thoroughly understanding this particular matter we shall endeavour to lay before the student some further explanations.

Deponent verbs, being passives in form, follow in their conjugation the passive form of the regular paradigms. Those having stems ending in *ă*, *ē*, and *ī* are inflected as passives of the First, Second, and Fourth Conjugations, and all the rest like those of the Third. But a deponent verb has more forms than the ordinary passive voice. It has not only the supine and the gerund, but four participles—viz. (1) the participle present, as *hortans*, admonishing, denoting the action in progress; (2) the participle perfect, as *hortatus*, having admonished, denoting the action as completed; (3) the participle future (active); as *hortaturus*, about to admonish, describing an action as future; and (4) the future participle (passive) or gerundive; as *hortandus*, meet to be admonished, which has a passive meaning, and accordingly is found only in those deponents which have a transitive signification. In the neuter gender, however, it occurs also in intransitive verbs.

Of many verbs there is both an active and a deponent form; as *pasco*, I give food, and *pascor*, I take food, or feed myself; *veho*, I carry, and *vehor*, I am carried, *i.e.* I ride; *verto*, I turn, and *vertor*, I turn myself, or I am turned. The participle present of such verbs has a double (which may be a doubtful) meaning; thus *vehens* may mean either "carrying" or "riding," and *vertens* either "turning" or "turning myself." Some verbs of this kind are used as real passives; as *comitor*, I am accompanied; *fabricantur*, they are made or manufactured; *populari*, to be plundered.

Real deponents—that is, those which do not possess an active form—are rarely used in a passive sense; though Cicero and Sallust, however, use *adūlor*, *aspernor*, *arbitror*, *criminor*, and *ulciscor* as passives; and the following perfect participles are, as Dr. Schmitz points out, used in a passive sense by the best authors: *abominatus*, *adeptus*, *auspicatus*, *amplexus*, *comitatus*, *complexus*, *commentus*, *commentatus*, *confessus*, *despicatus*, *detestatus*, *eblanditus*, *ementitus*, *expertus*, *exsecratus*, *interpretatus*, *ludificatus*, *meditatus*, *metatus*, *mensus* (*dimensus*), *moderatus*, *opinatus* (*necopinatus*), *pactus*, *partitus*, *perfunctus*, *periclitatus*, *stipulatus*, *testatus*, *ultus* (*inultus*), and some others which are used only by poetic license and by inferior writers.

The following deponent verbs are defective in their perfect participles, viz.:—

Comperior,	—, -īri,	*to know for certain.*	Irascor,	—, -sci,	*to be angry.*
Defetiscor,	—, -sci,	*to be weary or faint.*	Liquor,	—, -qui,	*to melt.*
Diffiteor,	—, -ēri,	*to deny.*	Medeor,	—, -ēri,	*to heal.*
Divertor,	—, -rti,	*to take lodging.*	Prævertor,	—, -rti,	*to outrun.*
			Reminiscor,	—, -sci,	*to remember.*
			Ringor,	—, -ngi,	*to grin.*
			Vescor,	—, -sci,	*to feed.*

As deponent verbs are conjugated like verbs passive the student is recommended to turn to the paradigm of the passive forms of (1) *Amor*, (2) *Moneor*, (3) *Regor*, (4) *Audior*, and, paying attention to the observations made regarding the participles, conjugate the following verbs in the same manner. Remember besides that verbs deponent, though passive in termination, as they are active in signification, are conjugated with gerunds and supines like a verb active.

Pres.	*Perfect.*	*Infin.*	
Auxilior,	auxiliatus sum *or* fui,	auxiliari,	*to help, v. dep.*
For,	fatus sum,	fari,	*to speak, v. dep.*
Hortor,	hortatus sum,	hortari,	*to exhort, v. dep.*
Culpor,	culpatus sum,	culpari,	*to be blamed, v. pass.*
Mutor,	mutatus sum,	mutari,	*to be changed, v. pass.*
Fateor,	fassus sum,	fateri,	*to confess, v. dep.*
Medeor,	medicatus sum,	mederi,	*to heal, v. dep.*
Moveor,	motus sum,	moveri,	*to be moved, v. pass.*
Loquor,	locutus sum,	loqui,	*to speak, v. dep.*
Irascor,	iratus sum,	irasci,	*to be angry, v. dep.*
Morior,	mortuus sum,	mori,	*to die, v. dep.*
Diligor,	dilectus sum,	diligi,	*to be loved, v. pass.*
Obruror,	obrutus sum,	obrui,	*to be overwhelmed, p.*
Queror,	questus sum,	queri,	*to complain, v. dep.*
Punior,	punitus sum,	puniri,	*to be punished, pass.*
Erudior,	eruditus sum,	erudiri,	*to be instructed, pass.*
Metior,	itus *and* mensus sum,	metiri,	*to measure, v. dep.*
Potior,	potitus sum,	potiri,	*to enjoy, v. dep.*

The perfect tense of deponent verbs is formed by supposing an active voice, from the supine of which comes the participle to which *sum* is added. For example, *imĭtor* forms the perfect *imitātus sum*, as if from *imĭto*, *āvi*, *ātum*, *āre*; and from this (imaginary) supine, *imitātum*, the participle *imitātus* is formed. To this participle *sum* is annexed, and thus *imitātus sum* results.

EXERCISE.—Search in the paradigm and find what parts the following examples resemble:—

Memoria recordātur,	*memory records.*
Deos precāri,	*to supplicate the gods.*

Me criminăris,	*thou accusest me.*
Miltiădes hortātus est pontis custōdes,	*Miltiades exhorted the warders of the bridge.*
Miratūrum esse,	*to be about to admire.*
Mirātum īri,	*shall be admired.*
Adulātus ĕrit amīcum,	*he will have flattered his friend.*
Functi sunt muneribus,	*they have discharged their duties.*
Merĭtum esse,	*to have deserved.*
Loquĕre nōmen tuum,	*tell thy name.*
Hic ortus est,	*this man has risen.*
Labĭtur ætas,	*age glides away.*
Sequĭtur patrem passĭbus æquis,	*he follows his father with equal paces.*

Many deponents would be more appropriately called reflexive verbs, *i.e.* verbs which indicate the reaction of an operation on an agent.

Apricor,	*I sun myself.*
Expergiscor,	*I wake myself, I awake.*
Fruor,	*I enjoy myself, I enjoy.*
Fungor,	*I employ myself, I discharge.*
Irascor,	*I am angry.*
Mutor,	*I change myself, I change.*
Pascor,	*I feed myself, I feed.*
Proficiscor,	*I set out.*
Queror,	*I complain.*
Recordor,	*I mind me, I remember.*
Ulciscor,	*I avenge myself.*
Utor,	*I occupy myself, I use.*
Vertor,	*I turn myself, I turn.*
Vescor,	*I feed myself, I live upon.*

IMPERSONAL VERBS.

Impersonal verbs, though used only in the third person singular, can have no noun or substantive pronoun for their subject. They state only in a general way that something happens or takes place, and their subject in English is the indefinite "it;" as *pluit*, it rains; *lĭcet*, it is permitted; *oportet*, it is a duty. Some verbs are always, or at least usually, impersonal, while others are used as impersonals only in a peculiar sense, being otherwise personal verbs; as *expĕdit*, it is useful (from *expedio*, I disentangle); *appāret*, it is clear (from *appareo*, I appear); *accĭdit*, it happens (from *accĭdo*, I fall in or upon a thing).

Among verbs which are always, or at least generally, impersonal are such as denote the various states of the weather; as *pluit*, it rains; *ningit*, it snows; *grandĭnat*, it hails; *lapidat* or *lapidatum est*, stones fall (from heaven); *lucescit* and *illucescit*, it dawns; *fulgŭrat* and *fulmĭnat*, it lightens; *tŏnat*, it thunders; *vesperascit* and *advesperascit*, it grows dark.

Verbs of this kind are sometimes used personally, oratorically, or poetically; as *dies illucescit*, the day is dawning. This is more especially the case with those referring to thunder and lightning; as *tonat*, *fulgurat*, *fulminat*, &c.; as *tonat orator*, the orator thunders; *occulis qui fulgŭrat ignis*, the fire which glitters in the eyes. With these we often find the subject *deus* or *Jupiter* conjoined; as *Jupiter fulminat*, Jove lightens, *i.e.* lightning flashes.

Active impersonal verbs have p… principally of the Second Con… *dĕcĕt*, it beseems; *dēdĕcĕt*… *pŭdĕt*, it shames; *pœnĭt*… *mĭsĕrĕt*, it moves pity;… *lĭquĕt*, it is clear; *attĭ*…

Impersonal verbs… thus:—

The persons are indicated by the case used after them; as

Present Tense.

Sin.	Oportĕt mē īrĕ,	*it behoves me*	*to go,*	or *I*	*ought to go.*
	Oportĕt tē īrĕ,	" " *you*		*you*	
	Oportĕt ĕum īrĕ,	" " *him*		*he*	
Pl.	Oportĕt nōs īrĕ,	" " *us*		*we*	
	Oportĕt vōs īrĕ,	" " *you*		*you*	
	Oportĕt ĕōs īrĕ,	" " *them*		*they*	
Sin.	Lĭcĕt mĭhi īrĕ,	*it is allowed me*	*to go,*	or *I*	*may go.*
	Lĭcĕt tĭbi īrĕ,	" " *you*		*you*	
	Lĭcĕt ĕi īrĕ,	" " *him*		*he*	
Pl.	Lĭcĕt nōbis īrĕ,	" " *us*		*we*	
	Lĭcĕt vōbis īrĕ,	" " *you*		*you*	
	Lĭcĕt iis īrĕ,	" " *them*		*they*	

The other moods and tenses proceed in the same way.

The following are impersonal verbs of other conjugations:—

Accĭdit, *it happens*	mĭhi, tĭbi, ĕi, &c.	Dēlectăt, *it charms*	mē, tē, ĕum, &c.
Contingĭt, *it befalls*		Jŭvăt, *it delights*	
Evĕnĭt, *it turns out*		Intĕrest, *it concerns*	mĕā, tŭā, ējŭs, &c.
Convĕnĭt, *it suits*		Rēfert, *it imports*	
Expĕdĭt *it is expedient*		Constăt, *it is acknowledged.*	

Real impersonals express changes of season, weather, &c.; as

Fulgŭrăt,	*it lightens.*	Lūcescĭt,	*it dawns.*
Ningĭt,	*it snows.*	Tŏnăt,	*it thunders.*
Plŭĭt,	*it rains.*	Vespĕrascit,	*it gets late.*

Intransitive verbs may be used impersonally in the passive voice; as *lūdĭtŭr*, there is playing, from *lūdō*, I play.

	Indic.	*Conj.*	*Infin.*
Present,	Lūdĭtŭr,	lūdātŭr,	lūdī.
Simple future,	Lūdētŭr.		lūsum īrī.
Imperfect,	Lūdēbātŭr,	lūdĕrētŭr.	
Perfect,	Lūsum est,	lūsum sīt,	lūsum essĕ.
Future perf.	Lūsum ĕrīt,		
Pluperfect,	Lūsum ĕrāt,	lūsum essĕt,	lūsum fŭissĕ.

The persons may be expressed by an ablative of the agent, in the manner shown below.

Present Indicative.

Sing.	Lūdĭtŭr ā mē,	*there is playing by me,*		or	*I play.*
	Lūdĭtŭr ā tē,	" "	*thee,*		*thou playest.*
	Lūdĭtŭr ăb ĕō,	" "	*him,*		*he plays.*
Plur.	Lūdĭtŭr ā nōbīs,	" "	*us,*		*we play.*
	Lūdĭtŭs ā vōbīs,	" "	*you,*		*you play.*
	Lūdĭtŭr ăb iis,	" "	*them,*		*they play.*

The ablative, being understood from the context, is often omitted.

The neuter gerundive is used impersonally with *esse* to express meetness or necessity; sometimes with dative of person.

Present Indicative.

Sin.	Lūdendum est mĭhi,	*there must be playing by me,*	or *I*	
	Lūdendum est tĭbi,	" " " *thee,*	*thou*	
	Lūdendum est ĕi,	" " " *him,*	*he*	
Pl.	Lūdendum est…			

…ive Mood.

Future.

	S. 2.	*S.* 3.	*P.* 2.	*P.* 3.
	ātō,	ātō,	ātōtĕ,	antō.
	ētō,	ētō,	ētōtĕ,	entō.
	ĭtŏ,	ĭtō,	ĭtōtĕ,	untō.
ītĕ.	ītō,	ītō,	ītōtĕ,	ĭunto.

Imperative Mood.

	Present. *S.* 2.	Present. *P.* 2.	Future. *S.* 2.	Future. *S.* 3.	Future. *P.* 3.
Am-	ārĕ,	āmĭnī.	ātŏr,	ātŏr,	antŏr.
Mŏn-	ērĕ,	ēminī.	ētŏr,	ētŏr,	entŏr.
Rĕg-	ĕrĕ,	ĭmĭnī.	ĭtŏr,	ĭtŏr,	untŏr.
Aud-	īrĕ,	īmĭnī.	ītŏr,	ītŏr,	iuntŏr.

Infinitive.

…res. Imperf.		Perf. Pluperf.	
Amā-	rĕ	Amāv-	issĕ.
Mŏnē-		Mŏnŭ-	
Regĕ-		Rex-	
Audī-		Audīv-	

Gerund.

	N. Ac.	G.	D. Abl.
Am-and-	um,	ī,	ō.
Mŏn-end-			
Rĕg-end-			
Audĭ-end-			

Infinitive.

Pres. Imperf.		Perf. Pluperf.		Future.	
Amā-	rī.	Amāt-	ŭs essĕ.	Amāt-	um īrī.
Mŏnē-		Mŏnĭt-		Mŏnĭt-	
Rĕg-	ī.	Rect-		Rect-	
Audī-	rī.	Audīt-		Audīt-	

Participle, Pres. Imp.

Am-	ans.
Mŏn-	ens.
Rĕg-	
Audĭ-	

Participle, Future.

Amāt-	ūrŭs.
Monit-	
Rect-	
Audīt-	

Supines.

	1.	2.
Amāt-	um,	ū.
Mŏnĭt-		
Rĕct-		
Audīt-		

Participle, Perfect.

Amāt-	ŭs.
Mŏnĭt-	
Rect-	
Audīt-	

Gerundive.

Amand-	ŭs.
Mŏnend-	
Rĕgend-	
Audĭend-	

illicita fœdatus facitus, He having defiled himself by permissible and forbidden things; *Optimus est portus pœnitenti mutatio consilio*, Change of purpose is the best security of the repentant; *Pudenda dictu spectantur*, (Things) disgraceful to be spoken of are witnessed.

The third person singular passive is very often used impersonally. This is especially the case with intransitive verbs which have no passive. This mode of speaking can scarcely be imitated in English. It is employed to signify that an action takes place without indicating its being done by any definite person or persons; as *curritur*, running is going on *or* people run; *vivĭtur*, people live; *ventum est*, people came *or* have come; *dormītur*, sleeping is going on *or* people sleep. The compound tenses of such passives have the participle only in the neuter; as *ubi eo ventum est*, when he had arrived; and the gerundive is used only in the neuter with *esse;* as *pugnandum est*, there is a necessity for (someone) fighting; *veniendum est*, there is a necessity for (somebody's) coming.

The following personal verbs have an idiomatic *impersonal* use, with the particular meanings here given:—

Stat,	*it is resolved.*	Solet, assŏlet,	*it usually happens*
Constat,	*it is agreed upon; it is well known.*	Accĭdit,	*it happens.*
		Accēdit,	*it is added.*
Præstat,	*it is better.*	Excĭdit,	*it has escaped me.*
Restat,	*it remains.*	Condūcit, Confert,	*it is serviceable,* or *conducive.*
Delectat,	*it is delightful.*		
Juvat,	*it is pleasant.*	Contingit,	*it happens; falls to the lot of.*
Vacat,	*[I, you, &c.] have leisure*		
Placet,	*[I, you, &c.] resolve.*	Sufficit,	*it suffices.*
Attĭnet,	*it relates to; concerns.*	Interest (*gen.*),	*it concerns; is of importance to.*
Appāret,	*it appears.*		
Decet,	*it is becoming.*	Creb(r)escit,	*[a report] spreads*
Dedecĕt,	*it is unbecoming.*	Convĕnit,	*it is suitable.*
Liquet,	*it is clear.*	Evĕnit,	*it turns out.*
Patet,	*it is plain.*	Expĕdit,	*it is expedient.*
Latet,	*it is concealed; unknown*	Fit,	*it happens.*

NEUTER-PASSIVE VERBS.

The three verbs, *fio*, *vapulo*, and *veneo*, are passive in meaning and construction, though active or neuter in form. They are therefore called neuter-passive.

Fĭo is used as the passive of *facio*, to make, and borrows its perfect tenses from it. The simple tenses and imperfect tenses are formed as if from *fiĕre.* Those compounds of *facio* that keep the *a* in the active (p. 520) have also their passive with *fio;* as *calefio*, *patefio*, &c.

The *i* is always long, except when followed by *r*. The third person singular present indicative—*fit*—may be made long or short at will.

Indicative Mood.

Present,	Fio, fis, fit, Fimus, fitis, fiunt.
Past imp.	Fiebam, &c.
Future,	Fiam, es, et, &c.
Perfect,	Fact-us sum, &c.
Past perf.	Fact-us eram, &c.
Fut. perf.	Fact-us ero, &c.

Imperative Mood.

Present, Fi, fite.

Infinitive Mood.

Present,	Fieri.
Perfect,	Factus, a, um, esse.
Future,	Factum īri.

Participles and Supine.

(Wanting).

Frustrari,	*to disappoint, frustrate.*	Reverti and Revertere,	*to return.*
Imitari,	*to imitate.*	Ruminari,	*to chew the cud.*
Impertiri,	*to share with, impart.*	Stipulari,	*to bargain, stipulate.*
Insidiari,	*to lie in wait for.*	Vagari,	*to go to and fro.*
Jurgari,	*to quarrel.*	Venerari,	*to worship.*
Lacrymari,	*to weep.*	Vociferari,	*to cry aloud, vociferate.*
Lætari,	*to rejoice.*		

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gaudere, to be glad; *soleo*, *solui* or *solitus sum*, *solere*, to be wont; *fido*, *fidi* or *fisus sum*, *fidere*, to trust, with its compounds *confīdo*, I trust, and *diffīdo*, I distrust, which have also *confidi* and *diffīdi*, in the perfect.

The only verbs which have the past active participle are a few of the deponent and semi-deponent verbs; such as *Conor*, *conari*, to endeavour; *conatus*, having endeavoured; *reor*, *reri*, to suppose; *ratus*, having supposed; *sequor*, *sequi*, to follow; *secutus*, having followed; *audeo*, *audere*, to dare; *ausus*, having dared.

DEFECTIVE VERBS.

Though several of the irregular verbs already mentioned on page 516 want some of their parts, and upon that account might have been called defective verbs, yet under defective verbs here we chiefly refer to such as want a very considerable number of their parts and are used only in a few tenses or persons, either from some peculiarity in their signification or some accident in their use, that is, "verbs which are specially incomplete in the machinery of their [normal] conjugation."

Many verbs have perfect without supine, as may have been seen in the tables given on pages 517–521. Many inceptive and other verbs have neither perfect nor supine; as *mītescō*, *pollĕō*, *fŭrō*, *fĕrĭō*, &c.

In point of fact the supines in *um* and *u* are in reality the accusative and ablative of verbal nouns of the Fourth Declension. The older grammarians employed the supine in *um* as one of the four parts from which to conjugate a verb, and consequently, in dictionaries, this supine is often supplied to verbs which never use and never require a supine at all, and which of course are defective in the grammatical sense of having no supines.

Of verbs which want many of their chief parts the following most frequently occur:—*Cœpī*, *mĕmĭnī*, *ōdī*, *nōvī*, *aio*, *inquam*, *fārī*, *cĕdo*, *quæso*, *forem*, *ausim*, *faxim;* the imperatives, *ăvē*, *ăpăgĕ*, *salvē*, *vălē*, and *ovāre*.

These four verbs, *cœpi*, *memini*, *novi*, and *odi*, have only the perfect tenses, and are therefore frequently called preteritive verbs—*Perf. Cœp-i*, I have begun; *memin-i*, I remember; *nov-i*, I know; *od-i*, I hate.

In those perfect tenses the last-named three take the signification of the simple or imperfect tenses; as *memini*, I remember; *memineram*, I was remembering; *meminero*, I shall remember, &c.

The foregoing verbs are conjugated like *rex-i;* thus:—

Cœpi.	Memini.	Novi.	Odi.
Cœperam.	Memineram.	Noveram.	Oderam.
Cœpero.	Meminero.	Novero.	Odero.
Cœperim.	Meminerim.	Noverim.	Oderim.
Cœpissem.	Meminissem.	Novissem.	Odissem.
Cœpisse.	Meminisse,	Novisse.	Odisse.
	Imp. Memento. Mementote.		

Cœp-i has two participles—viz. (1) future active, *cœptur-us*, about to begin; (2) perfect passive, *cœpt-us*, begun, whence are formed (1) a second perfect tense, *cœptus sum*, and (2) an impersonal perfect, *cœptum est*, used with passive infinitives; ... *des in murum jaci cœpti sunt*, From all ... thrown on the wall; *Postquam acrius* ... fight waxed fiercer, when it ... Cœpio is found in Plautus ... *valve*, ... remember thou, ... hang dow... as folding ... about to ... blood to end. *Odi-* ... up the en- ...

Loquor,	locutus sum,		
Irascor,	iratus sum,		
Morior,	mortuus sum,		
Diligor,	dilectus sum,	diligi,	
Obruror,	obrutus sum,	obrui,	
Queror,	questus sum,	queri,	
Punior,	punitus sum,	puniri,	
Erudior,	eruditus sum,	erudiri,	
Metior,	itus *and* mensus sum,	metiri,	
Potior,	potitus sum,	potiri,	

The perfect tense of deponent verbs is formed by ... from an active voice, from the supine of which comes the pa... to which *sum* is added. For example, *imĭtor* forms the perfect *imitātus sum*, as if from *imĭto*, *āvi*, *ātum*, *āre;* and from this (imaginary) supine, *imitātum*, the participle *imitātus* is formed. To this participle *sum* is annexed, and thus *imitātus sum* results.

Exercise.—Search in the paradigm and find what parts the following examples resemble:—

Memoria recordātur,	*memory records.*
Deos precāri,	*to supplicate the gods.*

SUBJUNCTIVE MOOD.

Pres.	—	aias,	aiat,	—	—	aiant.

Participle present, aiens.

The imperfect *aiebam* is sometimes used by the comic writers as a dissyllable—*aibam; ais, ait,* and *ain* (for *aisne*) are used as words of one syllable, and the perfect *ait* is like the present. *Ait* is used only between the words of a quotation.

INQUAM, *I say*, is very defective, the following forms only occurring:—

INDICATIVE MOOD.

	Singular.			Plural.		
Pres.	Inquam,	inquis,	inquit,	inquĭmus,	inquitis,	inquiunt.
Imperf.	Inquiebam,	-bas,	-bat,	-bamus,	-batis,	-bant.
Perf.	—	inquisti,	inquit,	—	inquistis.	

SUBJUNCTIVE MOOD.

Pres.	—	inquias,	inquiat,	—	inquiatis,	inquiant.

IMPERATIVE MOOD.

—	inque,	inquito,	—	inquite.

Participle present, inquiens.

This verb never begins a sentence, but stands between the words of a quotation; as *Tum ille nego, inquit, verum esse*, I deny, he then said, that it is true. The present *inquam* is also used as a perfect, and thus supplies the place of the first person of the perfect which is wanting.

FORE, *to be* or *to be about to be.*

SUBJUNCTIVE MOOD.

	Singular.			Plural.	
Imper. / *Plup.* } Forem,	fores,	foret,	foremus,	foretis,	forent.

Ausim, I may venture, I may run the risk of, I may dare, is an old perfect subjunctive, contracted from *ausus sim*, and is used with a present sense.

SUBJUNCTIVE MOOD.

Pres.	Ausim,	ausis,	ausit,	—	—	ausint.

Faxim is an old perfect subjunctive used by Plautus, Terence, Cicero, &c., for *fecerim; faxo*, an old second future for *fecero*.

Imper.	Faxim,	faxis,	faxit,	—	—	faxint.
Fut.	Faxo,	faxis,	faxit,	—	faxitis,	faxint.

The verb *fārī*, to speak, a deponent of the First Conjugation, wants the first person present of the indicative, and perhaps the whole present of the subjunctive; for we do not say *for* or *fer*, and rarely *feris, fetur*, &c. So likewise *daris* and *deris*, but not *dor* or *der*, to be given. The compounds of *fari—affari, effari, præffari,* and *profari*—have a few more forms, though these are rare, but the compounds of *daris*, as *addor, reddor*, are common. *Furere*, to be mad, is not used in the first person singular of the present indicative or subjunctive.

Most of the other defective verbs are but single words rarely to be found, and only among poets; as *infit*, he begins; *defit*, it is wanting. Some are compounded of ...
junction *si;* as *sis* for *si vis*, if thou ... passive voice. They are
vis, take if thou wilt; *sulti*... ...jugation:—*Oportĕt*, it behoves;
for *si audes*, if thou dare... ..., it misbeseems; *pĭgĕt*, it irks;
Av... ...ĕt, it repents; *tædĕt*, it disgusts;
...itĕ. *lĭbĕt*, it pleases; *lĭcĕt*, it is lawful;
IMPE... itĕ. ...*nĕt*, it relates; *pertĭnĕt*, it belongs.
... of the Second Conjugation are inflected

INFINI...

			Ind.	*Conj.*	*Infin.*	
...res. Imperf		1. Oport-				
Amā-		2. Dĕc-				
M...		3. Dēdĕc-				
	mē, tē, ĕum,	4. Pĭg-	ĕt,	ĕăt,	ērĕ.	*Pres.*
	nōs, vōs, ĕōs,	5. Pŭd-	ēbĭt.			*S. fut.*
		6. Pœnĭt-	ēbăt,	ērĕt.		*Imperf.*
		7. Tæd-	ŭĭt,	ŭĕrĭt,	ŭissĕ.	*Perf.*
		8. Mĭsĕr-	ŭĕrĭt.			*Fut. perf.*
	mĭhi, &c.,	9. Lĭb-	ŭĕrăt,	ŭissĕt.		*Pluperf.*
		10. Lĭc-				
	ăd mē, &c.,	11. Attĭn-				
		12. Pertĭn-				

Apăgĕ is the imperative of the Greek verb *apago*, and was used by the Romans in the sense of Begone! Avaunt!

Of *ovare*, to rejoice, celebrate a triumph, there occur *ovet, ovaret, ovandi, ovaturus, ovatus, ovandi,* and sometimes *ovans*.

While treating of defective verbs we may as well call attention to the fact that "the indicative and the subjunctive moods alone possess a complete apparatus of person endings, the imperative being sometimes merely the crude form of the verb, and the infinitive being strictly impersonal" (Dr. J. W. Donaldson's "Varronianus," p. 359).

It seems to be necessary also to note the following verbs as specially requiring attention, lest in reading—in which we shall soon now engage—mistakes may occur from the possibility of similarity being unknown. They have the same form, but differ (1) in conjugation and (2) meaning:—

All of the First Conjugation.		*Mostly of the Third Conjugation.*	
Aggĕro, āre,	*to heap.*	Aggĕro, ĕre,	*to bring to.*
Appello, āre,	*to name.*	Appello, ĕre,	*to come to land.*
Collĭgo, āre,	*to bind together.*	Collĭgo, ĕre,	*to assemble.*
Cōlo, āre,	*to strain through a sieve.*	Cŏlo, ĕre,	*to dwell, till, &c.*
Compello, āre,	*to address.*	Compello, ĕre,	*to force, compel.*
Dēlĭgo, āre,	*to tie.*	Dēlĭgo, ĕre,	*to select.*
Dĭco, āre,	*to educate.*	Dīco, ĕre,	*to say.*
Edŭco, āre,	*to bring up, foster.*	Edūco, ĕre,	*to lead forth, to bring up,* or *educate.*
Effĕro, āre,	*to make wild.*	Effĕro, ferre,	*to carry out.*
Fundo, āre,	*to found.*	Fundo, ĕre,	*to pour.*
Indĭco, āre,	*to disclose, point out.*	Indīco, ĕre,	*to declare publicly*
Mando, āre,	*to command.*	Mando, ĕre,	*to chew.*
Obsĕro, āre,	*to bolt* or *lock.*	Obsēro, ĕre,	*to sow.*
Prædĭco, āre,	*to proclaim.*	Prædīco, ĕre,	*to foretell.*
Rĕsĕro, āre,	*to unclose, open.*	Rĕsĕro, ĕre,	*to sow again.*
Vŏlo, āre,	*to fly.*	Vŏlo, velle,	*to be willing.*

These different verbs have the same spelling in the perfect—

Aceo, acuo—acui.	Fulgeo, fulcio—fulsi.
Consto, consisto—constĭti.	Lūceo, lūgeo—luxi.
Exsto, exsisto—exstĭti.	Mulceo, mulgeo—mulsi.
Insto, insisto—instĭti.	Păveo, pasco—pāvi.
Cresco, cerno—crēvi.	Pendeo, pendo—pĕpendi.
Frīgeo, frīgo—frixi.	

These different verbs have the supine spelled in the same way—

Cresco, cerno—crētum.	Succenseo, succendo—succensum.
Măneo, mando—mansum.	Tĕneo, tendo—tentum.
Pando, pătior—passum.	Vinco, vīvo—victum.
Pango, păciscor—pactum.	Verro, verto—versum.
Sto, sisto—statum.	

It not unfrequently happens that derivative verbs, chiefly inceptives and frequentatives, take the meaning of their primitives; thus both *hiare* and *hiscere* (for *hiascere*) mean to gape, to yawn; *conticere* and *conticescere*, to keep silence; *canere* (*cecini, cantum*) and *cantare*, to sing, &c.

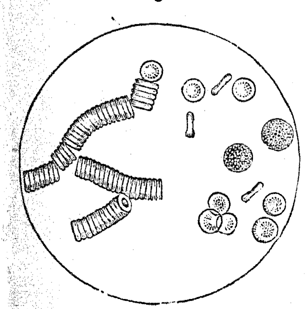
The registration ... nōbīs, " " " *us,* *we*
Lūdendum est vōbīs, " " " *you,* *you*
Lūdendum est ĕīs, " " " *them,* *they* } *play.*

In this, too, the dative case is often omitted; as *nunc est bĭbendum*, now we (*i.e.* men) must drink.

Impersonal verbs, properly speaking, cannot have either an imperative, a supine, or a participle. But a participle perfect passive in the neuter gender often occurs. These four impersonals, however, *lĭbet, lĭcet, pœnĭtet,* and *pŭdet*, have participles, with a meaning somewhat altered; as *lĭbens* signifies willing; *lĭcens*, free *or* unbridled; *licĭtus*, permitted *or* allowed; *licĭturum* is also used with the meaning of a thing which will be permitted; *pœnĭtens*, repentant; *pœnĭtendus*, to be repented of; *pŭdendus*, one to be ashamed of (also the gerunds *pœnĭtendum* and *pŭdendo*). The subjunctive is used instead of the imperative; as *pŭdeat te*, be ashamed! think shame! The following examples are given as illustrations of this statement:—*Quæ (res) tam libenti senatu laudarentur*, Which (things) were so praised by a willing, *i.e.* consenting or approving, senate; *Turba licens, Nāĭădes improbæ*, The shameless Naiads, a froward throng; *Ipse per licita atqu*...

somewhat saline in taste, giving out but a faint odour, and of a colour varying from bright scarlet to dark purple red, according as it is taken from the arterial or the venous circulation. It appears to the naked eye to be a homogeneous liquid, but when placed under a microscope and carefully examined it is found to consist of minute spheroidal corpuscles of an average diameter of $\frac{1}{3500}$ of an inch and $\frac{1}{12000}$ of an inch in thickness (fig. 1), floating in an almost colourless transparent lymph (*liquor sanguinis* or blood plasma). These corpuscular discs are of two kinds—red and white. The white or colourless corpuscles seem gradually to be converted into coloured or red ones, although the method and causes of this change have not as yet been clearly established. The white are more globular than the coloured, and the latter, when dried, tend to become star-shaped.

Fig. 1.



Corpuscles of Human Blood (magnified).

The blood carries on the phenomena of nutrition. It (1) collects, transmits, and imparts the substances requisite for the nourishment or rebuilding of the fabric of the tissues; (2) stimulates the organs through which it passes, and in its progress (3) removes from the tissues the waste matter of their fibre—such ingredients as can no longer be usefully employed in the operations of life, or may even be distinctly pernicious and injurious. That the blood may perform these functions effectively it must be in motion, so that it may exert its renovating, inspiriting, and depurgating power in every part of the human frame. This implies that man requires an organ of impelling force and organs for the proper transmission of the vital fluid. The *heart* is the central or chief agent in impulsion, and the tubular conduits through which the blood is conveyed are twofold: (1) *arteries*, and (2) *veins*.

The adult human heart is normally, *i.e.* as a general average, about the size of the closed hand of the special individual in whose body it beats—say about 5 inches long, $3\frac{1}{2}$ broad, and $2\frac{1}{2}$ thick, weighing in women from 8 to 10 ounces, and in men from 10 to 12. It is shaped somewhat like a pear, and is placed nearly in the centre of the chest, in a rather oblique position. The apex or pointed extremity lies directly under the space between the fifth and sixth ribs on the left side, and there its beat can be distinctly felt, and in persons of lean habit plainly seen. Its base or broader end goes upward, yet backward, and towards the right of the backbone. It is situated in the middle cavity of the thorax, immediately behind the sternum (or breast-bone), and between the two lungs (as shown in fig. 2), so that it is air-tight in its own special place, and is not pressed
Fut. per. the walls of the chest. Its frontal surface is
SUBJUNCTIVE MOOD. is flattened It is fixed in
Per ial bag and its attach-

Present,	Fi-am, as, &c.		
Past imp.	Fier-em, es, &c.	*Fut.*	*make* (wanting for the
Perfect,	Fact-us sim, &c.		meaning *to become*).
Past perf.	Fact-us essem, &c.	*Supine,*	Fact-u.

Vapulo, avi, atum, are (reg.) is used as the passive of *verberare*, to beat, as well as *verberari*, to be beaten.

Veneo, ivi or *ii, venitum* or *venum, ire*, is used as the passive of *vendere*, to sell, as well as *vendi*, to be sold.

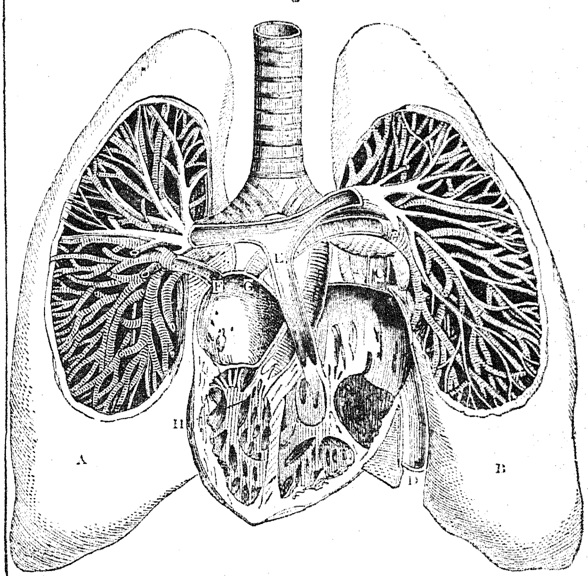
These six neuter verbs have a perfect participle used actively though passive in form. They are sometimes called neuter-passives, but are rather neuter-deponents—*Juratus* (*jurare*), having sworn; *potus* (*potare*), having drunk; *cœnatus* (*cœnare*), having dined; *pransus* (*prandere*), having breakfasted; *adultus* (*ad-olescere*), having grown; and *obsoletus* (*obs-olescere*), having grown out of use.

These four other verbs are sometimes called neuter-passive, because their perfect tenses are passive in form. They are perhaps better named neuter-deponents or semi-deponents—*Audeo, ausus sum, audere*, to dare; *gaudeo, gavisus sum,*

a small quantity of serum or lymph, amounting to about a drachm, to which the name of the pericardial fluid is given, is secreted. Thus, though shut off from the open air and inclosed within narrow bounds, this important organ possesses a means of adjusting itself to such movements as may slightly alter pressure and be firmly retained in its place, though not rigidly constrained therein.

Such is the place, appearance, and environment of the organ which moves the blood. Its internal conformation now falls to be described. When the heart has been laid open to examination it presents to view four chambers (as

Fig. 2.



Section of Heart and Lungs (seen from behind).

shown in fig. 2), two on the right side, B, which supply the lungs with blood, and two on the left, A, which supply the arteries. These two sets of chambers are separated from each other longitudinally by a strong partition composed entirely of muscular fibres called the *septum*, which completely shuts off the right side from the left side of the heart. Each of these sides is again divided laterally into two chambers by flaps of membranes, forming valves. The hollow purse-like cavities above the valves on each side are called from their outward appearance *auricles* (Lat. *auriculæ*, little ears). Those below the valves are called *ventricles* (Lat. *ventriculi*, little belly-like hollows). The two auricles, *i.e.* the upper chambers, occupy the base or broader part of the heart. Each auricle is connected with its corresponding ventricle by a wide opening, technically called the auriculo-ventrical orifice. All around the opening of these orifices there is placed a thin, tough membranous fibre, one side of which is strongly attached to and interlaced with the muscular wall of the ventricle, whose entrance it guards, while its
pugnari cœptum est, When the membrane on the pulmonic, *i.e.*
began to be fought more fiercely. *id valve*, consisting as it
and Terence. hang down from the

Memini has an imperative: *memento* as folding doors or
mementote, remember ye *or* you. blood to enter,

Odi has two participles: future active, *osurus* up the en-
hate; deponent, *osus, perosus*, or *exosus*, having hatefully from
entes is found in Petronius; *odiatur* in Seneca. aps,

Instead of *ōdi* we sometimes say *ōsus sum*, and always *exōsus, perōsus sum*, and not *exōdi, perōdi*. We say *opus cœpit fieri* or *cœptum est*, the work began to be done.

AIO. *I say, say yes*, or *affirm*, takes only the following forms:—

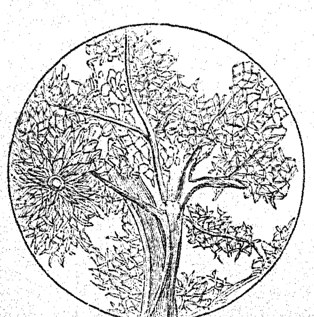
INDICATIVE MOOD.

	Singular.			*Plural.*	
Pres.	Aio,	ais,	ait,	—	—	aiunt.
Imperf.	Aiebam,	aiebas,	aiebat,	aiebamus,	aiebatis,	aiebant.

The right auricle of the heart is partly membranous and partly muscular. At its upper and back part the *vena cava superior*, C, opens into it, bringing the used-up blood from the head, the neck, and all the upper portions of the body. At its lower part the *vena cava inferior*, D, opens into it, bringing the used-up blood from all the lower portions of the body. By these entrances (*venæ cavæ*) the blood passes into and fills the right auricle, which then expands to its full compass. Immediately on this expansion being completed the right auricle contracts, and thus causes the blood to proceed through the tricuspid valve into the right ventricle below. This ventricle, which is much thicker and stronger, being composed almost entirely of tough muscular fibre, dilates on receiving the blood, the tricuspid valve closes, and then the ventricle contracts in order that the blood may be forced out again. From the right upper side of this ventricle the pulmonary artery, E, takes its origin, and just above the base of the heart divides into two branches, one of which proceeds to each lung. Through this artery, which is carefully guarded at its entrance by three crescent-shaped membranes called the semilunar valves, not holding a place within the limit of the heart, but situated in the first part of the pulmonary artery and in the *sinus Valsalva* (so called from the Italian anatomist), the contraction of the right ventricle drives the blood. This injected stream presses the semilunar valves against the walls of the arterial conduit, opens a passage for itself, and is carried along into the lungs, where it is divided and subdivided as the artery diffuses itself through the lungs until it has been attenuated into capillary tubes. In the course of traversing the lungs thus the dark, impure, used-up blood which had been brought into the heart by the *venæ cavæ* is purified, oxygenated, and regathered into the pulmonary veins, two of which proceed from each lung, and carry the bright scarlet fluid into the left auricle at its upper back part, F and G. Thus (1) the right ventricle, (2) the pulmonary artery, (3) the capillaries of the lungs, (4) the pulmonary veins, and (5) the left auricle, constitute the course of the pulmonic or respiratory circulation. In the course of this pulmonic journey the temperature of the blood is increased, its viscosity is modified by exhalation and absorption, its combinations are altered, and it is prepared to enter into the systemic or arterial circulation with the renewed physical properties necessary for effecting the phenomena of life as fresh arterial blood.

The greater systemic circulation begins with the left ventricle, into which the blood, now fitted for the fulfilment of the purposes of nutrition, is passed from the left auricle through the bicuspid valve. The walls of the left ventricle are nearly four times as thick as those of the right, and the irregular masses of muscular fibre known as *columnæ carneæ*, fleshy columns or pillars which stand out from its walls, are much larger and stronger than those of the right ventricle, because the systemic ventricle has obviously the most severe strain to bear and the greatest work to do. From the upper part of the left ventricle originates the great artery called the *aorta*, H. It rises about 3 inches above the heart, and then, curving a little to the left side, passes down through the chest into the abdomen, as seen at *f*, fig. 4. From the aortal curve three arteries branch off to form the conduits through which supplies are conveyed to the head and brain, the upper portion of the body, and the upper limbs. In its descending course the aorta divaricates or divides into branches differing in direction and diminishing in size, till at the lower extremity of the abdomen it subdivides into the iliac arteries, which carry downward the nourishment required by the lower extremities. The aortal passage, which is at its commencement nearly an inch in diameter, has its entrance, like that of the pulmonary artery, guarded by semilunar valves, yielding to the forward flow of the blood, but resisting any reflux. The pure wholesome blood—the "scarlet tide" of the poets—conveyed in the arterial conduit-pipes through the whole frame, is dispersed by them through all the animal tissues by a fine network of minute tubules called capillaries (shown in fig. 3 as seen through a microscope), whose walls, consisting of an exceedingly delicate network of membrane, allow the *liquor sanguinis* to impart nourishment to the tissues, and absorb through their film-thin coats the worn-out material which the tissues give off. The liquid thus charged with waste is gathered into the smaller veins, which convey it into larger ones, until at length all these reach one or other of the *venæ cavæ*, which discharge their contents into the right auricle. The systemic circulation passes along in due course through (1) the left ventricle, (2) the aorta, (3) the arteries, (4) the capillaries, (5) the veins, and (6) the right auricle. Thus the blood, within its carefully arranged and inclosed channels, moves in a double circle. It is driven in the one course from the heart to the body by efferent arteries, and from the body to the heart by afferent veins—the capillaries forming a fine transitional network between these differing conduits; and in the other course the blood is sent onwards from the heart to the lungs, and from the lungs back again to the heart. The pulmonary arteries carry impure blood from the right ventricle to the lungs, and the pulmonary veins carry back from the lungs to the left auricle of the heart bright, pure, wholesome blood; but in the systemic circulation the arteries carry forth through the frame a pure, bright, scarlet fluid, while the veins bring back in their more sluggish streams, along their many-valved courses, dark, impure blood.

Fig. 3.



Capillaries (magnified).

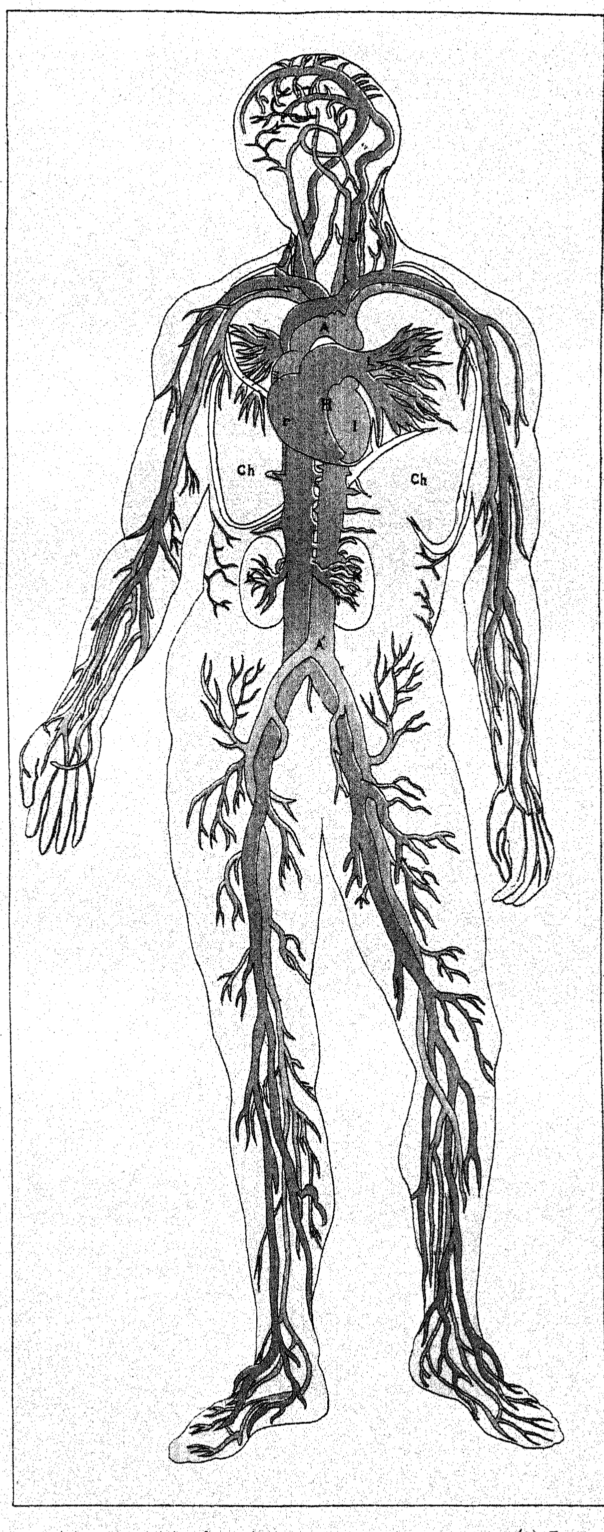
One part of the systemic circulation, exercising a peculiar function, has not yet been alluded to. It has received the specific designation of the *portal* circulation, and may now be explained. The veins which supply the stomach, the intestines (small and large), the spleen, the pancreas, and the gall-bladder, discharge their contents and accumulations through their capillaries and their connecting tubular channels into the *vena porta*, which, instead of emptying itself into the *vena cava*, ramifies through the substance of the liver, as if it were an artery, and connects itself with the capillaries of that organ, which is really nourished by the hepatic artery. The capillaries of the liver, containing not only the waste and used-up blood of that organ, but also that introduced into it by the *vena porta*, pass into the *vena cava inferior*, and thence enter into the general circulation. That this is a supplementary and secondary circulation, bringing work and not nourishment to the liver, is obvious; for we know that the blood which returns from the lower extremities ascends in the *vena cava inferior*, and running behind the liver flows directly into the right auricle; but the blood which proceeds from the visceral group above-mentioned, passes through their own capillaries, then goes through the ramifications of the portal vein, and next undergoes a new passage through the capillaries of the liver before it enters the hepatic vein, and is discharged by it into the *vena cava inferior* to be commingled with the other returning blood in the right auricle. That is to say, the blood of the portal circulation has passed through a double set of capillary network—viz. that of the intestines and that of the liver.

It is necessary to note here, too, that the heart receives the arterial blood required for its own nourishment from two special arterial conduits given off from the aorta immediately above the semilunar valves, and named the coronary arteries. This blood, the freshest and the best, is carried through the substance of the heart in order that it may discharge the function of nutrition, and is collected into the great cardiac or coronary vein, by which—as well as through the *foramina Thebesii*—it is carried and poured back into the right auricle.

The fluid mass of the blood is unresting in its course through the interior of the body. It traverses in a ceaseless round, and interpenetrates all the organs of the frame. Having imparted to them the healthy material by which they are upbuilt, and taken into itself the waste material of which

BLOOD—THE GENERAL DISTRIBUTION OF THE BLOOD-VESSELS.

THE ARTERIES ARE SHOWN IN RED, THE VEINS IN BLUE.



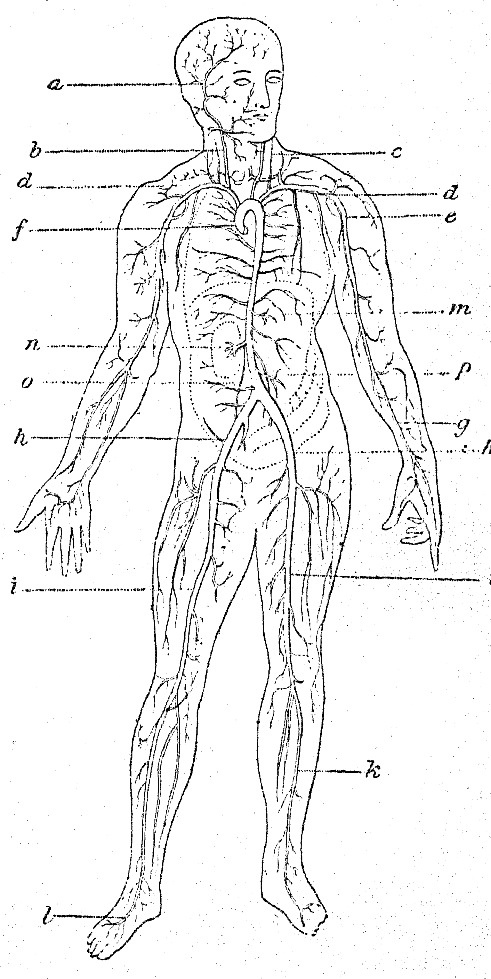
H, the **heart**. l, left side. r, right side. Arising from the heart is the main artery **Aorta.(A)** The letter is put on the vessel at some distance from the heart, near where it gives off the branches (in red) for the head and arms, and at the point where it arches backwards and downwards to pass through the chest and belly till at A′. it gives off branches for the legs. Running alongside of the arteries are represented in blue, **veins.** At **K**, is represented the position of the **kidneys** and their veins. L, represents veins of the **lung**. J, jugular vein. **Ch**, outlines of the chest

the body requires to get rid, it returns to put itself again into contact with the air, that—being by respiration enriched with renewed ingredients of strength, and freed from pernicious acquisitions—it may again distribute through the frame renovation, health, and power. Blood is truly, as Bordeu has well defined it, "fluent flesh," made up of those substances which are requisite for the nutrition of every part of the body, in which all the elements of the material products partaken of in food are combined and fused into a plastic fluid, by whose aid all the various tissues of the human frame are repaired, increased, and preserved in health and vital power.

The apparatus of the circulatory system, besides the main central reservoir and engine, the heart, whose constant throbbing keeps the continual currents of nutrition in motion, includes also the inclosed conduits through which the sanguine fluid is conveyed to every tissue of the body, called the *arteries* (Gr. *arteria*, air-ducts), because being always found void of blood in bodies subjected to examination after death, they were by the early anatomists regarded as wind-pipes. The clarified, scarlet, oxygenated blood proceeds from the left ventricle of the heart by the single great arterial trunk (*f* to *h* in fig. 4), called the *aorta* (Gr. *œirō*, I bear or carry), which sends off its branch-channels to all parts of the body. The aorta is regarded by anatomists as divided into three portions—viz. (1) *arch* (*f*, fig. 4) or ascending curve, the course of which is upward, forward, and inclined towards the right till it reaches the level of the second segment of the sternum, and then descending to the third dorsal vertebra; (2) the *thoracic* aorta, extending to the diaphragm and slantingly reaching the central plumb-line of the spine; and (3) the *abdominal* aorta, from the diaphragm to the lower margin of the fourth lumbar vertebra, where it divides into the two iliac arteries, *h*, *h*. From the arch there is given off five arterial canals—viz. (1) and (2) the two coronary arteıies which supply nourishment to the heart, (3) the innominata, (4) the left carotid, *c*, and (5) the left subclavian, *d*. The thoracic aorta supplies (1), through two (or three) bronchial arteries, blood for the tissues of the lungs; (2) through three (or four) small arteries nutriment to the œsophagus; and (3) through the intercostal arteries—ten on left and nine on right side—the supplies required by the walls of the chest. The abdominal aorta provides two sub-branches, called the phrenic arteries, to the diaphragm; the cœliac axis passing by three large tubes into the stomach, liver, and spleen; the mesenteric arteries, of which the *superior* nourishes the smaller (and part of the large) intestines, and the *inferior* the (remainder of the) large intestines; the renal and suprarenal—two of each—supplying the kidneys; the spermatic artery and the lumbar arteries nourishing the loins. It thereafter bifurcates to supply the lower extremities, and terminates in a small thin tube known as the sacra-media.

The following tabular view of the aortic and arterial circulation condenses this matter into small space, while the annexed cut will give an idea of the positions of the chief arteries of the body.

Fig. 4.



The Arteries of Man.

a, The temporal artery; *b*, *c*, carotid arteries; *d*, *d*, subclavian arteries; *e*, axillary artery; *f*, aorta; *g*, radial artery; *h*, *h*, iliac arteries; *i*, *i*, femoral arteries; *k*, tibial artery; *l*, artery of foot; *m*, gastric artery; *n*, renal artery; *o*. superior mesenteric; *p*, inferior mesenteric.

The AORTA furnishes	I. At its origin, ...	(1) The anterior cardiac or left coronary artery.
		(2) The posterior cardiac or right coronary artery.
	II. At its curve, ...	(1) On the right the bronchio-cephalic: 1. The carotid artery. 2. The subclavian.
		(2) On the left " 1. The carotid. 2. The subclavian.
	III. In the chest, ...	(1) The right and left bronchials.
		(2) The œsophagian arteries.
		(3) The posterior mediastines.
		(4) The intercostals.
	IV. In the abdomen, ...	(1) The right and left diaphragmatic arteries.
		(2) The cœliac axis.
		(3) The mesenteric (superior).
		(4) The mesenteric (inferior).
		(5) The suprarenal.
		(6) The renal.
		(7) The lumbar, &c.
	V. At the bifurcation, . . .	The right and left iliac, each divided into 1. Internal iliac. 2. External iliac.

The arterial tubes are very complex in their structure. Arteries are sheathed in cellular tissue, and their substance is disposed in threefold layers, of which the first is external, elastic, and distensible, containing the bloodvessels and nerves of the artery itself; the second medial, muscular, contractile, but brittle; and the third internal, smooth,

transparent, brittle, and lined with epithelium, forming the conduit through which the blood is distributed. These arterial canals are of two sorts, which, however, freely anastomose, *i.e.* communicate their contents to one another—(1) *nutritive*, supplying the requisite material to the various tissues; and (2) *transmissive*, carrying along their contents to where they are required. The femoral artery (*i*), for example, divides into the deep femoral of supply for the thigh, and the superficial femoral of transmission, carrying on supplies (*k*, *l*) for the leg and foot.

The blood is driven by the heart into the aorta and its numerous branches. By the force of the heart's continual contraction and expansion a pulsating motion is communicated to the entire fluid, which passes through the arteries and is superinduced in them. Hence the jerking alternate *tic-tac* or *lub-dub* heard in the heart-beat and felt at the wrist and elsewhere, in what is called the *pulse*, and hence also we know when an artery is cut, because the blood flows from it not in a smooth-flowing stream, but with a kind of jerky progress. In order that they may be the less exposed to accidents arteries are in general deep-seated, and even when they are cut the opening made by the wound is contracted by the curling up of the tissue of the artery within its cellular sheath. By this the flow of blood is stopped, and by and by the clot which gathers outside of the cut is aided by another within the artery, which together keep the edges in adhesion, while the tissues throw out a lymph which conduces to the healing of such wounds. As the arteries impel the blood from the heart, while the veins convey the blood to the heart, we have in the method of that fluid's flow, as well as in its colour, a means of distinguishing arterial from venous injuries. As the arteries diminish in their course until they terminate in mere capillary filaments, both the volume and the velocity of the blood decrease in proportion to its distance from the heart, while in the veins both its volume and velocity increase as it approaches the heart.

When the blood has finished its journey through the arteries it has parted with its nutritive elements and has become laden with impurities and waste. It cannot then improve the body or support life. From the little hair-like capillaries in which the arteries end it passes into the equally minute capillary conduits of the veins which inosculate with them. These veins are similar in substance to the arteries, but are thinner in their outer elastic coat, and are furnished internally with small semilunar pouch-forming valves, in order that, as the blood is now to be conveyed from the extremities towards the heart, the fluid may not be able to press backwards and overload these vessels at any point, but may be kept in constant progress. These valves are most numerous, as we might expect, in the veins of the lower extremities, in which, of course, the blood requires to ascend, in opposition to the force of gravity. They are not found, because not required, in (1) very small veins generally, and (2) in some large veins, especially the pulmonary, renal, portal, hepatic, and the *venæ cavæ*. They are pervaded by nutrient vessels, but not by nerves. Their external coat consists of connective or areolar tissue and of elastic fibres running lengthwise, and in some a longitudinal network of unstriped muscular fibre is supplied as a means of additional strength. The contractile middle coat of the veins consists of layers of muscular and elastic fibres, the former being disposed, in many cases, circularly round the tube. The inner coat of these vessels consists of layers of elastic longitudinal fibres, having an epithelial fine smooth membranous lining. The veins retrace, in general, the pathways of the arteries, reuniting into enlarged trunks at important points, and at last forming in the *venæ cavæ* the immediate conduits to the heart. The *vena cava superior* pours the venous blood brought in from the bronchio-cephalic region, *i.e.* from the upper limbs, head, neck, &c., augmented by the chyle—which is let into the main stream of the blood at the junction of the jugular and left subclavian vein—into the right auricle. The *vena cava inferior* pours into the same receptacle the blood brought in from all the organs of the trunk of the body and from the lower extremities, including the blood returned from the portal circulation and the chyle which has been absorbed into it by the intestinal veins. The inflow of the superior vein is downwards, while that of the inferior is turned somewhat aside, so as to prevent them from interfering with one another. The influx of blood into the two auricles causes the special act of simultaneous contraction called systole (Gr. *systolē*, a straitening), and when the blood has passed out of these into the ventricles there is an equally simultaneous dilatation called diastole (Gr. *diastolē*, a separation). Experimenters state that the systole occupies only about one-third of the time required by the diastole. Though each cavity has its diastole and its systole, in common usage it is to the alternate expansion and contraction of the ventricles that these words are applied. The act of systole propels the blood through the uniform and smooth outlet into the commencement of the aorta, and communicates a shock to the whole arterial system. That series of effects produced by the action of the left ventricle upon the arteries is called the pulse (Lat. *pulsus*, a stroke), perceptible to sight, hearing, and touch. We all know that a physician tests the methodic movements of the heart by placing his finger on the radial artery which plies its office immediately under the skin of the wrist, when "feeling the pulse." If the ear is applied to the chest two sounds may be heard, each of which is distinct from that of the heart-beat: (1) one dull and longish, when the ear is placed near the ventricle, just over the fifth and sixth ribs; (2) one sharp and quick, when the ear is placed at the curve of the aorta and the joining of the first rib with the breast-bone. When the hollow of the knee of one leg is laid upon the knee of the other leg, the toe of the foot of the rested leg will be seen to move up and down at each beat of the pulse, and hence probably the inclination of the leg so laid to indulge in a rhythmical see-saw motion.

The frequency of the pulsations of the heart varies much in different individuals, but generally according to a regular gradation at different ages, becoming slower from infancy up to old age. In persons of adult age from seventy to seventy-five beats in the minute is the usual average, and in men of sixty years of age the pulse usually beats sixty. The pulse in females is quicker than in males. It varies, besides, according to many modifying causes. Exercise quickens it, rest calms it; even on sitting up it will be found four or five beats quicker than while lying down. In some few it may be felt beating very little more than forty in the minute. The whole quantity of blood in the body of a full-grown man has been calculated at 35 lbs. of 12 oz., so that if the heart beats seventy-five times in a minute, and expels 2 oz. from each ventricle at each beat, the whole blood will pass through the circulation in two minutes and a half.

In treating of digestion we have shown how in the alimentary laboratories the hidden chemistry of life transforms our food into a nutritive fluid; in detailing the operations of the circulation of the blood we have explained how the physical river of life is distributed throughout the whole of the tissues of the human frame. There are marvels of chemical conversion performed in the rapid transit of the fluid which transcend our ken. Forth through the systemic circulation the selfsame vital stream passes into the various tissues of brain, bone, muscle, nerve, &c.; but how it is that the alchemy of vitality transmutes this fluid matter into membrane and cuticle, nerve-fibre and muscular-tissue, bone and gristle, saliva and gastric juice, wax, fat, milk, bile, tears, and all the other solid and liquid elements of the body, has not yet been discovered. When we trace the phenomena of the respiratory circulation and of the action of the atmospheric air within the lung tissues, we shall learn some what more of the actual processes of vitality, but we shall still be a vast distance from fully comprehending the architecture and the chemistry of the earthly house of this fleshly tabernacle in which for a life-time we dwell.

We present in the following synopsis an outline of the circulatory system.

I. The circulation of the blood presents the following four varieties, viz.:—

(1) Arterial or Systemic; (2) Pulmonic; (3) Portal; (4) Cardiac or Coronary.

II. The organs of the circulation are—

(1) The Heart: (*a*) right or venous; (*b*) left or arterial.

(2) Arteries: (*a*) pulmonary; (*b*) aortal. (3) Veins: (*a*) superior; (*b*) inferior. (4) Capillaries: (*a*) systemic; (*b*) pulmonary. (A tabular view of the arterial system is given, p. 617.)

III. The phenomena of the heart's action are—

(1) Right Auricular Systole; (2) Right Auricular Diastole; (3) Left Auricular Systole; (4) Left Ventricular Diastole; (5) Pulsation.

IV. The appendages of the heart are—

(1) Inlets (supply-pipes): (*a*) superior vena cava; (*b*) inferior vena cava. (2) Outlets: (*a*) aorta; (*b*) pulmonary artery.

BOOK-KEEPING.—CHAPTER VII.

THE LEDGER—DEBTOR AND CREDITOR—RULES FOR POSTING —SPECIMEN OF LEDGER ACCOUNTS.

IT has already been stated that the Ledger is the completion and crown of scientific book-keeping. In it all the scattered items, entries, or transactions which have been made, assorted, and grouped in properly classified order find their final depository and ultimate registration. The second important matter to be learned in regard to the use of the Ledger is the method of *posting*. Posting is the carrying of the separate specific entries arranged in the Journal, &c., and the placing of these entries in their proper accounts and in a proper way in the Ledger. This posting may be of two sorts, viz., (1) simple and (2) compound.

(1) Simple posting is that form of entry in which there is only a single transcription requiring to be made in transferring it from any preliminary book into the Ledger—*e.g.* in entry from the Cash Book, such as that, p. 526, which makes Wills & Co. Dr. to Broadcloth.

(2) Compound posting is that form of methodical registration of the entries carried from any of the preliminary books into the Ledger, wherein there arises the need of transferring entries in which (*a*) one "Dr." has two or more creditors, or (*b*) one "Cr." has two or more debtors; *e.g.* in the first instance, if Messrs. Wills & Co. had ordered a bale of broadcloth and it had been sent them, the sum due on account of it when paid might require to be distributed as a Dr. entry in "cash," in "charges," and in "insurances," or if there were several persons engaged in a venture there might require to be entered into the Cr. of a profit-and-loss account the names of these several persons—John Doe, Richard Roe, Peter Smart, &c.

We must here, however, explain a special technical use of Dr. and Cr. which emerges at this point of our exposition. In the Ledger we require to recognize three forms of debit and credit, viz., (1) personal; (2) real; (3) nominal, fictitious, or symbolical.

(1) A personal Dr. or Cr. is one who, as an individual or a firm, transacts business on credit with a merchant, &c., and the entries made in the Ledger under his name, and posted to his debit or credit, are placed under what is called a personal account, having a mercantile, commercial, or convertible value.

(2) A real Dr. or Cr. is an article of merchandise, a thing dealt in by a merchant, the accounts of which are kept under their respective names, and as the Latin word *res* signifies *a thing*, and these accounts concern themselves with things, they are called *real* (from Lat. *realis*). They are, in fact, the accounts of the different kinds of property in which a merchant trades—cash, bills, articles of merchandise, &c.

(3) Nominal, fictitious, or symbolical accounts indicate accounts which are neither personal nor real—such as *stock*, representing the constantly changing business of the merchant; profit and loss, representing the gain made or the losses borne in the course of the merchant's transactions, the *result* of his adventure, business, &c., during a given time.

It is a principle in book-keeping that "every debtor must have a creditor, and *vice versâ*." In other words, everything that comes into a business must be accounted for and balanced by what goes out of it in the way of trade. Hence, (1) *a thing received* is debtor to the thing given for it—*e.g.* broadcloth is Dr. to cash, and cash Cr. to broadcloth; (2) a thing received upon credit is Dr. to the person from whom it was got, and the person who got it is Cr. for what is given in return; and (3) the person to whom a thing is sold or delivered on credit is Dr. to the thing delivered, and of course the thing delivered is Cr. to the person to whom it was delivered. This may be more readily understood, perhaps, if we put it in this way:—

Dr.	*Cr.*
(1) When a customer purchases goods on trust he becomes Dr. and the merchant Cr., and the merchant makes his entry on the Dr. side of the customer's account.	(1) When a merchant supplies goods on trust he becomes Cr., and the customer Dr., and the merchant makes his entry on the Cr. side of his account.
(2) When the customer pays for the goods got—in money, bills, &c.—the sum is entered to the Dr. of the merchant's and to the Cr. of the customer's account.	(2) When a merchant receives money, &c., in payment of goods supplied, the sum is entered on the Cr. of the customer's and on the Dr. of the merchant's account.

In brief, the whole law of book-keeping, properly understood, resolves itself into *In*, Dr.; *Out*, Cr.; *i.e.* whoever (or whatever) gets is Dr., and whoever (or whatever) is given is Cr.

The general rules for balancing each debit entry by a credit one may be more specifically set down as follows:—

1. A personal account is *debited to* a real account when the person whose name it bears receives property (of any kind in a business way) from a merchant, or it has been sent to him in accordance with his order; and if any expense has been incurred, or any business has been transacted, as the agent or on behalf of another, by a merchant, a personal account is debited to a profit-and-loss account.

2. A personal account is *credited by* a real account when a merchant receives property from the person whose name it bears, or when it has been sent to the merchant in accordance with his order; and if any expense has been incurred, or business transacted, on behalf of a merchant, a personal account is credited by a profit-and-loss account.

3. A real account is *debited to* a personal account when goods have been received by the merchant from a person, or been sent by his order; and is *credited by* a personal account when a person receives property from a merchant, or it is sent on order to him.

4. A profit-and-loss account is *debited to* a personal account when a person incurs expenses or transacts business on a merchant's order; and is *credited by* a personal account when a merchant incurs expenses or transacts business at the request or order of a person.

5. A profit-and-loss account is *debited to* a real account, when goods are risked in any speculation, either in adventure on commission or in copartnery; and is *credited by* a real account when the returns of the said risk are received.

6. A real account is *debited to* a profit-and-loss account when the net return of a speculative transaction has been received; and is *credited by* a profit-and-loss account when goods are risked on any speculative transaction.

7. A general profit-and-loss account is *debited to* (1) a personal account, or (2) to a real account when loss has been incurred; and is *credited by* (1) a personal or (2) a real account when a profit has been made.

8. A personal or a real account is *debited to* the general profit-and-loss account when loss has accrued; and is *credited by* the general profit-and-loss account when gain has been made.

In short, these laws of posting may be generalized into this one simple and efficacious rule—of which the foregoing may be regarded as definite illustrations and confirmations—*Debit* all Drs. for the sums *they owe*, and *Credit* the Crs. for the sums *owing to them*.

The order of opening accounts in the Ledger is generally as follows: (1) Real accounts—*e.g.* Stock, Private Accounts, Cash, Petty Expenses, Bills, Goods, of each several sort, &c.; (2) personal—*i.e.* individual accounts; and (3) nominal accounts — as Interests, Charges, Commissions, Profit and Loss, &c.

The *order* in which the entries are usually posted into

the Ledger—in a general merchant's counting-house—is this: (1) Cash Book, (2) Bill Book, (3) Goods or Day Book, (4) Stock or Warehouse Book, (5) Invoice Book, and (6) any other subsidiary books, such as Sales Book, Accounts Current, Petty Expenses, &c.

We give below specimens of Ledger entries in the several classes of accounts, which, that they may exhibit the greater variety, we supply (imaginarily) from several kinds of business, viz. :

I. A Personal Account.

LEDGER.

Dr. WILLIAM B. EVERETT. Cr.

1888.	Date.		£	s.	d.	1888.	Date.		£	s.	d.
May	9	To $6\frac{1}{2}$ lbs. cheese, at 10*d.* per lb.	0	5	5	May	12	By Cash, ...	4	0	0
"	11	" 40 lbs. tea, at 2*s.* 6*d.* "	5	0	0	"	20	" "	3	10	0
"	13	" 60 lbs. sugar, at $3\frac{1}{2}$*d.* "	0	17	6	"	30	" Balance, ...	1	2	6
"	18	" 15 lbs. tea, at 2*s.* 9*d.* "	2	1	3						
	"	" 40 lbs. sugar, at $2\frac{1}{2}$*d.* "	0	8	4						
			8	12	6				8	12	6
"	31	" Balance, ...	1	2	6						

II. A Real (*i.e.* Goods or Property) Account.

Dr. SUGAR. Cr.

1888.	Date.		£	s.	d.	1888.	Date.		£	s.	d.
June	3	To Cash, 1 hhd., ...	9	5	0	June	6	By Cash, 2 hhd., . .	20	13	6
"	5	" Ross & Co., 5 "	49	5	0	"	11	" Thos. Carr, 1 " . .	10	3	9
"	13	" Cash, 1 "	9	10	0	"	14	" Wm. Welsh, 3 " . .	29	15	0
"	31	" Profit and Loss gained, . . .	1	17	3	"	30	" Balance on hand, 1 " . .	9	5	0
			69	17	3				69	17	3
"	31	" Balance on hand, ...	9	5	0						

III. A Nominal Account, *i.e.* One used merely for Convenience.

Dr. PROFIT AND LOSS. Cr.

1888.	Date.		£	s.	d.	1888.	Date.		£	s.	d.
Nov.	4	To Salary of Cash Clerk (for month),	10	0	0	Nov.	31	By Sundries, Discounts, &c. (for month),	5	10	0
"	11	" Cash Sundry Small Account, .	5	7	6	"	"	" Fruit, ...	3	14	6
"	"	" " Rent, Taxes (for month), .	15	0	0	"	"	" Flour, ...	16	15	8
"	30	" " Sugar loss, ...	3	4	6	"	"	" Tea, ...	41	5	0
"	"	" " Cheese loss, ...	2	6	9	"	"	" Butter, Eggs, Bacon, ...	5	2	6
"	"	" " Capital Acc. (for net gain),	36	8	11						
			72	7	8				72	7	8

Dr. BALANCE SHEET. Cr.

1888.	Date.		£	s.	d.	1888.	Date.		£	s.	d.
July	1	To Capital, ...	1000	0	0	July	1	By Stock (see Stock Book), . . .	1283	1	11
"	"	" Debts, as per list—				"	"	" House Fixtures and Furniture, &c.,	891	4	0
		1. Cash borrowed from Royal Bank,	512	10	0			" Cash on hand, ...	285	2	3
		2. Goods bought on credit, . .	631	5	0			" Debts due, as per list, ...	200	0	0
		" Amount of net gain, ...	515	13	2						
			2659	8	2				2659	8	2

GEOMETRY.—CHAPTER VII.

THE COMPARISON OF TRIANGLES—THE CONDITIONS AND RESULTS OF TRIANGULAR EQUALITY.

If the student will look back to Proposition xxii. (p. 528), he will notice that it is assumed by Euclid that the two circles used in the demonstration shall cut each other, though it is not "so nominated in the bond." He will, however, observe on reflection, that the sum of the radii of the two circles is, by hypothesis, greater than the distance between their centres, and hence the two circles must cut each other. If the circles do not cut one another, they must, as Proclus noted long ago, lie either (1) wholly within, or (2) wholly without one another. They cannot, however, lie wholly within each other, for if the circle K H L lie wholly within the circle D K L, the lines F G and G H would be together less than F D, but they are not. They cannot lie wholly without each other, for if they did, F D and G H would together be less than F G; but they are not, for any two of the lines must be greater than the third. It may not be amiss here to suggest that if any two of the

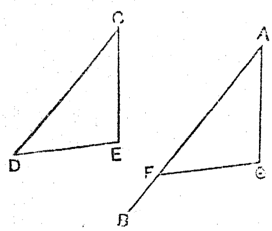
given lines are equal, the triangle F K G, which they will form, must be an isosceles one; so that from this proposition we may deduce a method of describing an isosceles triangle.

Passing on to consider the work set before us in Euclid, Book I., we reach the problem given us in

Proposition XXIII.

At a given point in a given straight line to make a rectilineal angle equal to a given rectilineal angle [i.e. to construct it so that the given straight line shall form one of the adjacent sides of the required rectilineal angle].

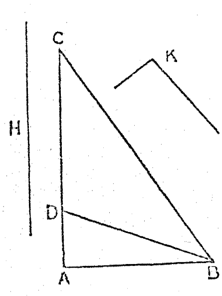
In solving this problem we proceed thus:—Let A B be the given straight line, and A the point given in it, and let D C E be the given rectilineal angle. In C D, C E, take any points D and E, and join D E. Then, as we have already learned to do (in I. 22), let us make on A B the triangle A F G, the sides of which shall be equal to the three straight lines, C D, D E, and E C, and in such a way (by I. 8) that A F shall be equal to CD, A G to C E, and F G to D E.



The angle F A G, thus formed, shall be equal to the given angle D C E, because F A, A G, are equal to D C, C E, each to each, and the base F G is equal to D E, and it is described upon the line A B at the point A. Q.E.F.

A very elegant supplementary problem may be performed in dependence on this one—viz. one of the angles at the base of a triangle, that base itself, and the sum (or aggregate) of the two remaining sides being given, to construct the triangle.

First of all, let K be the given angle, A B the given base, and H the sum of the two remaining sides. Then, at the point A in the base A B, make (as in I. 23) the angle B A C equal to K, and (by I. 3) A C equal to H. Join C B. Now, at the point B in C B make (I. 23) angle C B D equal to A C B, then D A B is the triangle required; for as D C B equals D B C, B D equals D C. Add to both of these lines D A, then B D and D A are together equal to C D and D A, that is, B D and D A together equal C A, which, by construction, equals H. The angle A was made equal to K, and the triangle D A B is constructed of the elements and in the manner required.



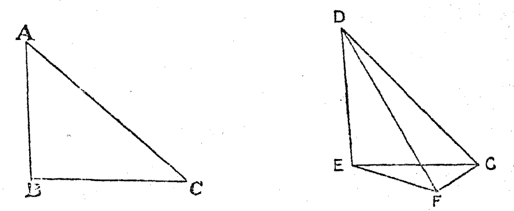
The next two propositions are theorems, and the converse the one of the other. They ought therefore to be diligently compared with each other both as to process and result. It will be found advantageous to read the two propositions one after the other, noting each word; or having written them out side by side, to observe particularly how the one proposition forms the counterpart of the other.

Proposition XXIV.

If two triangles have two sides of the one equal to two sides of the other, each to each, but the angle contained by two sides of the one greater than the angle contained by the two sides equal to them of the other, the base of that which has the greater angle shall be greater than the base of the other.

Given A B C, D E F, two triangles having the two sides A B, A C, equal to D E, D F, each to each, namely, A B to D E, and A C to D F, but having the angle B A C greater than the angle E D F, then the base B C is also greater than the base E F.

Of the two sides D E, D F, let D E be the side which is not greater than the other. Then, at the point D in D E (by I. 23) make the angle E D G equal to B A C; make also (I. 3) D G equal to A C or D F, and join E G, G F. Because A B equals D E, and A C equals D G, these two sides are equal each to each, and their contained angle B A C is equal to E D G. Therefore the base B C is equal (I. 4) to the base E G. Again, because in the triangle D F G, D G is equal to D F, the angle D F G is equal to the angle D G F (by I. 5);



but the angle D G F is [obviously] greater (axiom 9) than the angle E G F, therefore the angle D F G is also greater than E G F; much more then is the angle E F G greater than E G F. Now, because in the triangle E F G, the angle E F G is greater than the angle E G F, and (by I. 19) the greater side is subtended by the greater angle, the side E G is greater than the side E F. But E G has been proved to be equal to B C, and therefore B C is greater than E F. Q.E.D.

In this theorem the construction has been made, as Simson does it, by taking D E, "the side which is not greater than the other," in order that the demonstration may be at once abridged and simplified. If the construction had been taken, as Proclus, Campanus, Commandine, &c., do, from the greater side, then three cases would have arisen, each requiring separate demonstration, according as the point F would fall (1) upon, (2) above, or (3) below the bases. It ought, in strict geometrical reasoning, however, to have been shown that the point F must always fall below the base. This justifying proof may be given. Let the student call that point in D F which is intersected by E G, H; then as D E is not, by hypothesis, greater than A B, the angle D G E is not greater than the angle D E G (I. 5 and 18). But the angle D H G is greater than D G H, and therefore (by I. 19) the side D G is greater than D H. D F, however, is equal to D G, and hence it is also greater than D H. On this account the point H must be between D and F, and if D F is made equal to D G it must be produced below the base E G.

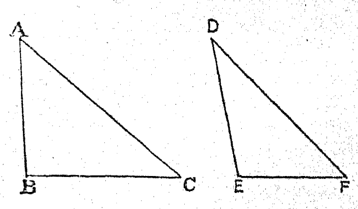
The student will find it a good exercise to construct the three (possible) cases and prove them. He will find an elegant solution given in "The Library of Useful Knowledge, Geometry," p. 9.

We may now proceed to consider the converse of what has just been proved—viz.

Proposition XXV.

If two triangles have two sides of the one equal to two sides of the other, each to each, but the base of the one greater than the base of the other, the angle contained by the sides of that which has the greater base is greater than the angle contained by the sides of the other.

Let A B C, D E F be two triangles, which have the two sides A B, A C equal to the two sides D E, D F, each to each, A B to D E and A C to D F; but let the base B C be greater than E F, then the angle B A C shall be greater than the angle E D F.



If the angle at A is not greater than that at D it must either be equal to or less than it. It is not equal, for if so B C would equal E F, but this it does not. Neither is it less, for then (as has been shown in I. 24) B C would be less than E F, which, by hypothesis, it is not. As the angle at A is neither equal to nor less than the angle at D, it must be greater, wherefore, &c. Q.E.D.

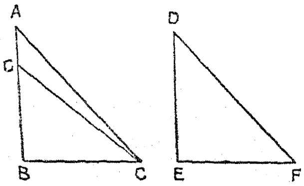
We have now reached the last of the three cases in which two triangles are in all respects equal to one another, viz. :—(1) when (I. 8) they have three sides respectively, *i.e.* each

to each, equal; (2) when (I. 4) they have two sides and their included angles respectively equal; and (3)—that case which we are now about to consider—when (I. 26) they have two angles and the included side equal, each to each. These three conditions of equality are very frequently highly serviceable, not in geometrical operations alone, but also in the arts and in the mechanical sciences. It is of great consequence, therefore, to have a correct knowledge of the conditions indispensable to the accurate construction of equal triangles, for if any one of these conditions is not rigorously fulfilled there will be some angle or some side in the one not equal to the corresponding angle or side in the other. We shall take occasion to point out the need of caution in this matter when we have had a glance at the theorem immediately presented to our view in the succeeding

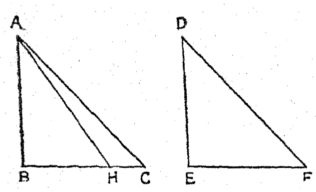
PROPOSITION XXVI.

If two triangles have two angles of the one equal to two angles of the other, each to each, and one side equal to one side, viz.:—(1) *either the sides adjacent to the equal angles, or* (2) *the sides opposite to the equal angles in each; then are* (1) *the other sides equal, each to each, and* (2) *the third angle of the one is equal to the third angle of the other* [i.e. *the two triangles are congruent or equal in every respect*].

This falls clearly into two cases. First, let B C equal E F—the sides *adjacent* to the angles that are equal, each to each. Then, if A B, D E be unequal, one of them must be the greater. Let A B be the greater, make B G equal to D E, and join G C. Then because B G equals D E, B C is equal to E F, and angle A equals angle E, therefore the angle (I. 4) G C B equals angle F; but the angle A C B also equals F, so that the angle G C B is equal to A C B, the less to the greater, which is impossible. A B is therefore not unequal to D E, that is, it is equal to it. We have then, in the two triangles, A B C, D E F, the two sides, A B, B C, and the included angle B in the one, equal to the two sides, D E, E F, and the included angle E in the other, each to each, and A C equals D F, and angle D is equal to angle E.

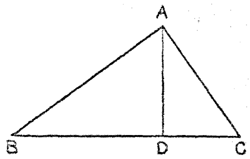


Second, let AB equal D E—the sides *opposite* to the equal angles. In this case also the other sides shall be equal, each to each, A C to D F, B C to E F, and angle A to angle D. If, however, B C, E F are unequal, let B C be the greater; make B H equal to E F, and join A H. Then because B H equals E F, and A B D E, the two sides A B, B H equal D E, E F respectively, and they contain equal angles; therefore A H equals D F, and the triangle B H A equals E F D (I. 4). This E F D, however, equals B C A, and in consequence B H A equals B C A, that is, the exterior angle equals the interior and opposite, which (I. 16) is impossible. So then, B C is not unequal to E F, but equal to it; and A B equals D E; therefore the two sides A B, B C are equal to the two sides D E, E F, each to each, and they contain adjacent angles; therefore A C equals D F, and A B C equals D E F, so that if two triangles, &c. Q.E.D.



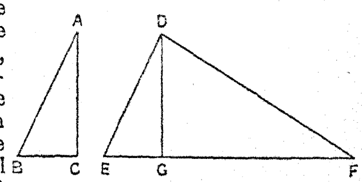
The reasoning in these two propositions is technically called "reasoning *per impossibile*," *i.e.* through refutation. Refutation is reasoned contradiction. Here it takes the form of showing, by the evidence of sense (in the figure) and of reason (in the demonstration) that if what has been laid down as a truth, *i.e.* asserted, is not so, then two ideas which mutually contradict, and therefore destroy, each other—in other words, two ideas which can neither be conceived together nor united in thought—would require to be acknowledged as right and true. But both by the laws of thought and things, contradictions are coexclusive. If one is accepted as true, the other must be rejected as false. The law of non-contradiction is inexorable. To accept—proper knowledge of them being possessed—of two ideas which are contradictory (or necessarily involving contradiction) of each other as true, is, as the human mind is constituted, impossible, and Euclid often employs this species of argument to prove that any denial or non-acceptance of his propositions involves the traverser in contradiction. In all cases where such reasonings are used we must be careful in observing that the contradiction is full, clear, direct, and explicit—covering the precise point raised in the endeavour to refute or deny.

The caution that requires to be given here is this—that the two sides (one in each triangle) which are, in this theorem, supposed to be equal, must either (1) lie *between* the angles in each triangle respectively equal, or (2) be opposite to a similarly situated equal angle in each triangle, otherwise the two triangles will not fulfil the requisites of equality. For, though two triangles have two sides of the one equal to two sides in the other, and one angle in the one equal to one angle in the other, if it is not contained by (*i.e.* lying between) the equal sides, the triangles *may be* unequal; or though they have two angles and a side in the one equal to two angles and a side in the other, unless the equal sides are similarly placed with respect to the angles, no proper conclusion can be drawn regarding the equality of the triangles. For instance, in the right angle B A C annexed, if we draw a perpendicular from the angle at A to the base B C, it will divide the whole triangle into two others, A D B and A D C, having two angles equal each to each—viz. A D B to A D C, and A B D to C A D—as is in the latter case proved by VI. 8. The side A D is likewise common to both of the triangles; and yet these triangles, though similar, are not *necessarily* equal, because the common side A D neither (1) lies between nor (2) is opposite to equal angles.



Founding almost upon the same fact, we may introduce here a supplementary theorem, viz.:—If two right-angled triangles have the three angles of the one equal to the three angles of the other, each to each, and if a side of the one be equal to the perpendicular let fall from the right angle upon the hypotenuse of the other, then shall a side of this latter triangle be equal to the hypotenuse of the former.

Let A B C, D E F, be two rectilineal triangles, right-angled at C and D, having also the angles D E F and E F D equal, each to each, to A B C and C A B, as well as the side A C of the triangle A B C equal to the perpendicular D G, drawn to the hypotenuse E F of the triangle D E F; then the side D E of the triangle D E F is equal to the hypotenuse A B of the triangle A B C. Because A C equals D G, and the two angles A C B, A B C, of the triangle A B C are equal to the two angles D G E, D E G, of the triangle D E G, each to each, the line D E equals (by I. 26) A B.

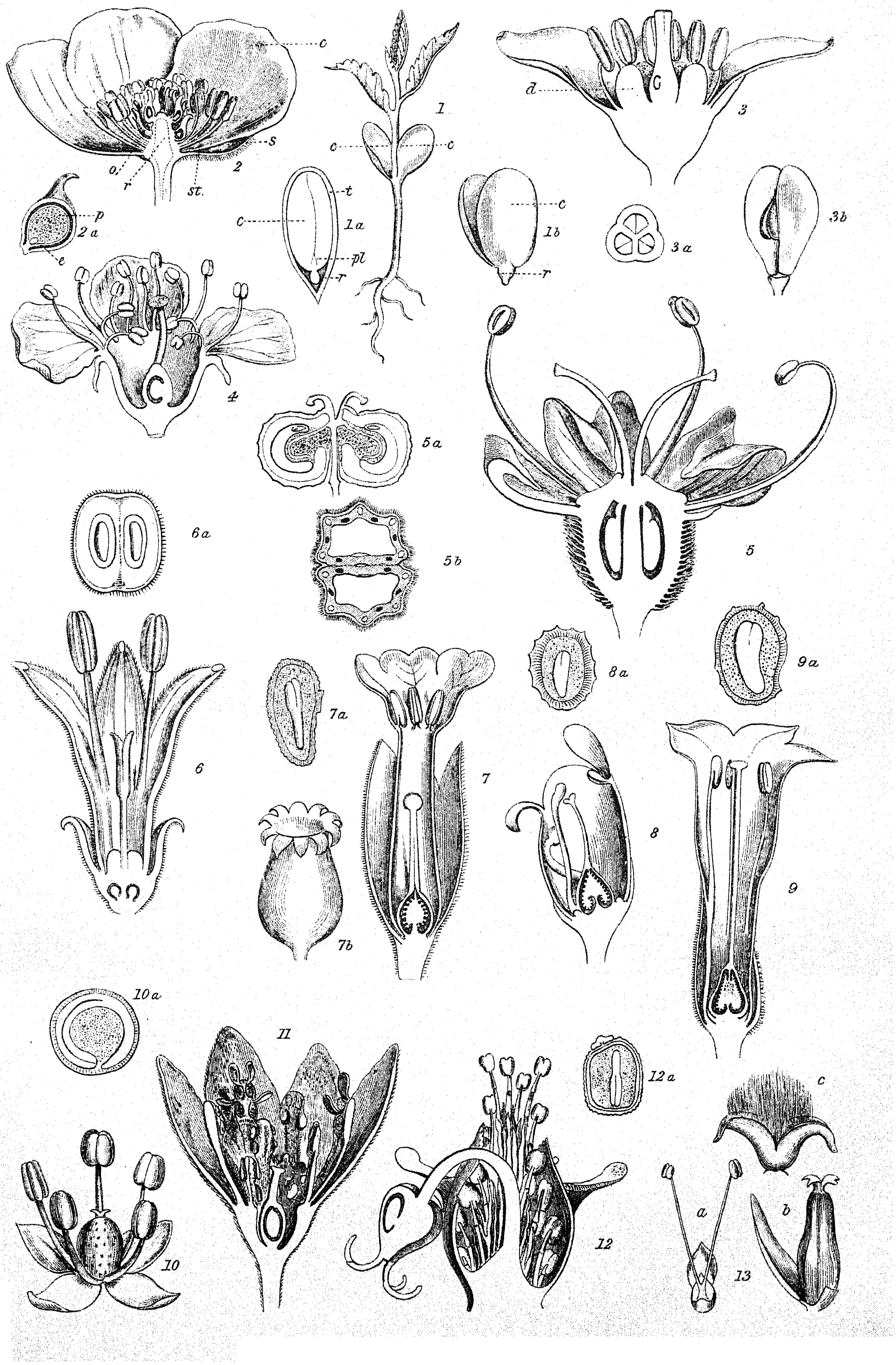


All the propositions concerning triangles are of such practical importance that accuracy of verification as regards the facts and their results demands the closest attention, and has elicited much ingenuity. One eminent modern geometrician avers that "Triangles are as much the elements of all figures as the letters [of the alphabet] are of words."

BOTANY.—CHAPTER VII.

FERTILIZATION—FLOWERS—CALYX—COROLLA—STAMENS—PISTILS—THE USES OF THESE PARTS—CLASSIFICATION OF PARTS.

MAN'S mind requires to construct definitions, but nature is not easily confined within them. Accurate as may be the nicely dividing lines drawn between part and part or species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and species, and carefully chosen as the words may be in which the characteristics of each are expressed, experience is always presenting something that transcends definition. Hence many of the statements made concerning the phenomena of nature—which we tend to stereotype into rules or laws—are confronted by exceptions and inconsistencies. A plant, for instance, is usually defined as a vegetable organism consisting of root, stem, leaves, flowers, and fruit; yet to the eye the mistletoe hangs its empearled boughs on apple-tree or thorn without genuine root, and the orchid perches upon tropical trees, fed upon air and decaying matter without touch of soil. The tulip and the crocus, though they have flower-stalks, have no proper stem. Similarly, as a rule, leaves are green, and flowers are those portions of plants which are coloured with strange bright hues and odorous with the sweet perfumes which they breathe around; yet we find the leaves of many begonias with silver-spotted upper surfaces and claret-coloured beneath. The cocoa's (Pachira) ovate-leaf is crimson-dyed, the croton plants (Euphorbiaceæ) have yellow-tinged and rose-hued leaves, while in the Dracæna the young leaves are quite rosy. In many such cases the foliage-leaves are so curiously enriched with colour that they look more like flowers than the actual blossom of the plant itself, insomuch that in comparison with the lovely tints of their foliage such plants may be regarded by the ordinary observer as relatively flowerless, their floral leaves being plain, simple, and unornamented in comparison. Yet for all this we must abide by definition, and proceed as best we may to mark off to the understanding the scientific significations attached to the term *flower*.

The flower is that special part of a plant which is formed to produce, contain, and ripen the means by which the plant may be reproduced and multiplied by seed. Reproduction is not the act of the plant which is developed from, but of the plant which develops, the seed. The vital process of nutrition has an end. The effecting of that end commences with the earliest vital movement which the generated germ makes towards growth, *i.e.* development to a determinate form and size as an individual organism, and the evolution of the means of preserving and multiplying the race, the reproduction of new individuals resembling itself. The parent-plant originates in a seed, and expends its vitality in the formation of germs potentially vital, in circumstances suitable to their appropriation and assimilation of nutritive materials. Deriving life from previous similar plants, plants communicate life to other succeeding plants by the production of embryonic germs capable in themselves of development and evolution. The general law of nature is that every perfect plant, whether annual, biennial, or perennial, herb, shrub, or tree, is the product of a seed, a perfect plant being one "whose end is in itself" as a primordial force. Hence the flower (Lat. *flos*, a blossom, and Gr. *phleo*, I teem or am full) is that which is full of generative power, and may be regarded as including all that co-operates to the production of seed.

The small leaves out of whose axils flowers grow are called *bracts*. Bracts of different kinds receive different names (as has been explained at p. 530). It is rare for plants to have no bracts; yet in the genus Brassica, the turnip-family, they are conspicuously absent. The bract region is the space between the true and perfect foliage leaves of a plant and the base of the flower-calyx. The flower is the last and most finished product of plant-life. Milton rightly therefore designates it "the bright *consummate* flower;" for *fruit*, "the joy of plants," the treasure-house and harvest-home of plant-life, is botanically the seed-pod in its mature condition, ready for taking up a new life and for producing new plants. One part of the flower protects the fluids required by the reproductive organs of the plant, so that they may be able to discharge their functions, and aids in digesting them; another matures that fluid and fits it for carrying on and securing the success of that function. The former is an extension and expansion of the cortical system, and the latter of the cellular tissue of the plant, and these constitute the floral integuments. A complete flower consists of (1) *calyx*, (2) *corolla* (Plate VIII., fig. 2 *c*), (3) *stamens* (fig. 2 *st*), and (4) *pistils* (fig. 2 *d*), to which we may, in some cases, add a *disc* (fig. 3 *d*).

The *calyx* (Gr., cover, shell, cup) is the outermost of those *whorls* or modified leaves which, while the blossom is yet a bud, incloses and protects the interior contents. It is usually of a green and leafy texture, though sometimes it is of a different colour. In the fuchsia, for instance, the brightly-coloured, funnel-shaped, four-cleft outer leaf which forms the special beauty of that graceful pendulous flower is the calyx. The calyx presents usually the character of leaves, and in some cases of monstrosity they are converted into the ordinary leaves of a plant. This is frequently seen in the rose. The structure consists of cellular tissue, traversed by vascular bundles in the form of ribs and veins containing spiral vessels, which can be unrolled, delicate woody fibres, and other vessels, the whole inclosed in an epidermic covering having stomata on its outer surface, which corresponds to the under surface of the leaf. It may consist either (1) of several separate independent pieces, or (2) of a definite number of pieces joined and growing together from their bases up to their edges. These component parts are called *sepals* (Lat. *sepio*, I inclose). Sepals are generally simple and without stalk. When they grow together into a sort of tubular vase, they are called monosepalous or gamosepalous (Gr. *monos*, one; *gamos*, wedlock); when they consist of two separate parts they are disepalous; of three, trisepalous; of four, tetrasepalous; of five, pentasepalous; and of many, polysepalous. The calyx usually grows detached from the *pistil*, leaving its sides free, as in borage (Plate I., fig. 8), hyacinth, geranium, &c., in which case it is called *inferior*. In Eschscholtzias, as the poppy, &c., the large and beautiful disepalous calyx separates from the expanding flower, and is thrown off like a cup, or may be plucked off, as is often done by children, like an extinguisher from a candle. In this case it is called *caducous*. In the case of the Ranunculaceæ, as crowsfoot, buttercup, spearwort, &c., their pentasepalous calyx generally falls off when flowering, and is known as *deciduous*. When the calyx is attached to the surface of the pistil, it is called *superior* or *adherent*, as in the currant, parsley, myrtle, &c. When the calyx remains till the fruit is ripe, in which case it is frequently much enlarged and more brightly coloured, it is termed *persistent*, as in the Love-apple (*Physalis edulis*) and Chenopodium (Plate VIII. fig. 10).

Different designations are also given to differing shapes of the calyx. When it resembles a drinking vessel or vase, (1) *cup-shaped;* when it has the form of a bell, (2) *campanulate;* when it has a long cylindrical tube, while its border is short and spreading or salver-shaped, (3) *hypocrateriform;* when it is like an inverted cone, (4) *infundibuliform* or funnel-shaped; when, having a short tube, its border spreads so that it looks like a wheel, (5) *rotate;* when it forms a kind of surrounding sheath, (6) *tubular;* when, being tubular, its sepals are also regularly angular, (7) *prismatical;* when contracted at top so as to give it a bellied or inflated form, (8) *ventricose;* when shaped like a top, (9) *turbinate;* and when its parts are so united, as in the Self-heal (*Prunella vulgaris*), that they form two interfitting lips, (10) *labiate*, &c. The calyx is regarded as *regular* when all its parts are equal in size, alike in form, and —as in the Goosefoot (*Chenopodium album*)—symmetrically united; and *irregular* if the sepals are unlike in form, unequal in size, and not symmetrically joined, as in the Common Milkwort (*Polygala vulgaris*). The sepals, with reference to their outline, margin, and apex, receive the same designations as are given to foliage leaves (see page 429). Sepals, in regard to direction, are, when turned upward, like the Common Anchusa (*Alkanet officinalis*), (1) *erect;* when turned inward, (2) *connivent;* when spreading outward, like borage, (3) *divergent* or *patulous;* and when their ends are turned downwards, like the Evening Primrose (*Œnothera biennis*), (4) *reflexed*.

The external envelope of a flower is considered the calyx. Occasionally, however, there is an outer additional set of sepals—as in the strawberry, the mallows, potentilla, &c.—which constitute an *epicalyx*. The acorn-cup and the prickly case of the chestnut are different modifications of the epicalyx. Some botanists call this an *involucre*, but involucre, properly speaking, incloses several flowers, while the epicalyx incloses only one. Botanists employ the fine-sounding useful term *perianth* (Gr. *peri*, round about, and *anthos*, a flower) to

signify the floral-envelope when the outer whorl of the calyx is not readily distinguishable from the inner whorl of the corolla (Plate VIII., figs. 6, 8). Sometimes it is used to denote the calyx of flowers that have no corolla, again it is applied to a calyx while petaloid, and at other times it is employed with reference to the calyx and the corolla when both are present, but similar in colour and texture. But it is only rightly used when it designates both calyx and corolla, is equivalent to wrapping, and signifies whatever surrounds the stamens and pistils, whether (1) single, when no corolla is developed, when it is equivalent to calyx, or (2) double, when both are present, but very much alike; and it is not rightly applied when these surroundings or wrappings consist only of *bracts* or form a true *involucre*. In the Star of Bethlehem there occurs a single perianth, the outer part of which is herbaceous, like a calyx, and the inside petaloid, like a corolla, and clearly exhibiting the fine structural gradation from the leafy to the more delicate texture. In the white lily, again, the calyx and corolla are both present in a double perianth; but both are white, and the difference between each is only to be discovered by examination. The calyx, of course, as the sheltering leaves, are hardly so soft or so purely white as the sheltered inner leaves. The flower of the wild corn-poppy is properly a corolla, not a perianth. Its calyx falls off when the bud begins to open. In the dandelion (Plate I., fig. 19), thistle, groundsel, &c., the calyx is represented by the tuft of fine hairs called the *pappus*, or by a fine stalk crowned by a feathery pappus. Some valerians take a similar calyx—the limbs of the calyx being either membranous or like a pappus. In fact the calyx often takes irregularly the appearance of the corolla, and can only rightly be determined in some cases by strict investigation. Monocotyledonous plants—wherein, like the embryo or the cotyledon, all the parts are single—have only one floral integument, the perianth. They have no cortical system, and because they want the structure out of which it is formed, they have no calyx, but are often supplied with a spathe or sheath, an epidermal structure analogous in function. Dicotyledonous plants having the double structure have also the double perianth of calyx and corolla. As monocotyledonous plants are more cellular than dicotyledonous ones, their flowers are frequently greater in size, more gorgeous, and more patulous.

The corolla is the whorl of leaves which, when there are two floral envelopes, are found next to and within the calyx. It is that part which we are in the habit of calling, in ordinary language, the flower. It usually imparts beauty to the plant, and yet it may be wanting without injury to the *real flower*—*i.e.* the stamens and pistils, as in the nettle (Plate I., fig. 13). In some cases, like the tulip, it is scarcely distinguishable from the calyx, hence both together are designated the perianth. The readiest way to learn to distinguish between calyx and corolla is to take a flower in full bloom, say a rose (fig. 3), and pull off one by one the leaves of the gayest and most conspicuous part; you will then have left in your hand the stalk and the green leaves which were round the corolla. These form the calyx, which, you will notice, is polysepalous. The corolla you have removed, and in the centre of what the corolla had surrounded there will be a bunch of yellow thread-like filaments. These are the *stamens*, and in the middle of them, though not perhaps easily recognized by a beginner, is the *pistil*. The same process may be taken with other flowers; the buttercup, with its prominent yellow five-petalled corolla; the wall-flower (fig. 5), four-petalled and unsymmetrical; the apple-blossom, whose petals alternate with the sepals of the calyx, &c.

The corolla varies considerably in form. Its leaves receive the name of petals (Gr. *petalos*, outspread). These, when they unite and form a tube, are called *monopetalous*, but when they are all distinct *polypetalous*. The Greek prefix *poly*, usually signifying many, denotes in botany generally a number of free and unconnected parts (of whatever kind they may be). Polypetalous corollas receive distinguishing names, of which the following are the most frequently employed—viz. (1) *rosaceous*, rose-like, composed of several petals, regularly arranged and taking a circular, cup-like shape; (2) *papilionaceous*, butterfly-like, consisting of five petals, of which one, erect, is called the standard (*vexillum*); the two smaller ones below, the wings (*alæ*); and the two lowest, united in the form of a boat, the keel (*carina*), *e.g.* the pea; (3) *caryophyllaceous*, nut-leaf shaped, like the pink, the petals of which have a long narrow part, designated claw (Lat. *unguis*), inclosed in the calyx, and a broad spreading upper part, technically termed the limb, above it; (4) *cruciform*, cross-like, having four petals arranged in the form of a Greek cross—*i.e.* like the sign plus (+) in arithmetic; (5) *liliaceous*, lily-like, having six regular petals or segments in a polyphyllous perianth, as in the tulip; (6) *nectiferous*, sparred, as the violet. Monopetalous or gamopetalous corollas take forms and names similar to those of the calyx; *e.g. campanulate*, like the campanula (Plate I., fig. 2); *hypocratiform*, like the auricula; *infundibuliform*, like the convolvulus; *rotate*, like the mezerean; *tubular*, like the blue gentian; *urceolate* or pitcher-shaped, like the arbutus; *personate* or mask-like, as in the snapdragon (fig. 9); *ringent* or gaping, like sage; *labiate*, like thyme; *ligulate*, tongue or strap-like. Tournefort called such plants *semiflosculous*, *i.e.* having a corolla of one petal split on one side and spread out in the form of a tongue or strap, toothed at the extremity. In such flowers as the Compositæ—dandelion (fig. 19), daisy, marigold, &c., this form of corolla is common, and appears in all the florets of the dandelion, for instance, and only in the florets of the rays of others, like the daisy and the aster. The *corollets* are usually flat, spreading out towards the end and tubular only at the base. Sometimes, within or upon the corolla, and before we come to the stamens, there is a kind of saucer or cup, as in the daffodil, or a ring of scales, as in the passion-flower (fig. 17); this is known as the *corona* or *coronet*, and must not be confounded with the corolla.

Andrœcium (Gr. *andros*, of a male, and *oikos*, a house) is the name given to the male apparatus, *i.e.* the ring of stamens in a plant taken collectively. It is found next the corolla in the inside, and forms the third whorl or set of whorls of modified leaves which form the male system of plants, of which, for the most part, a flower consists. The parts of which it consists are stamens, each of which, if normally developed, has the following parts, viz., (1) a thread-like stalk or filament, and (2) a little bag or case in which there is contained a fine, flour-like powder called *pollen* (Lat., fine dust). The pollen is set free when the flower is thoroughly ripe by the opening out of the valves of the anther; and when the pollen is examined under a microscope it is found to consist of very minute cells, differing in size and shape in different plants — some globular, some oval, others square; some like the mallow, toothed like a watch-wheel; others like the sun-flower, like a prickly ball, &c. If the pollen—as is rarely the case—is absent, the anther is said to be *sterile;* if the filament is absent, the anther is termed *sessile*.

The filaments are usually distinct from each other, as they are in the strawberry. Sometimes, as in the mallow, they grow together in a tube; they are then called *monodelphous*. At other times, as in the pea (Plate I., fig. 6), where nine stamens grow together in a parcel and one stands by itself, they are *didelphous*. Not quite so frequently they are combined into more than two parcels, as in the Hypericaceæ, and are then called *polydelphous*. If the stamen filaments grow from below the base of the *ovarium*, in a manner so isolated and independent as to be capable of removal from the flower without interfering with any other organ, and they remain on the flower when the calyx or corolla is pulled off, they are called free or *hypogynous*. Such are the stamens of the buttercup, the poppy, the rhododendron, &c. If they grow attached to the calyx, like the rose and the lilac, they are called *perigynous;* if they adhere to the corolla, they are epipetalous; and if they grow on the summit of the ovarium, they are *epigynous*. Epigynous stamens are sometimes free, as in the favourite white-flowered green-house plant Deutzia, and sometimes, as in the fuchsia, they adhere to the calyx. In some flowers, like lilies and daffodils, the stamens, being large and tall, are well shown, and they are sometimes ornamented with coloured hairs. In the cactus they resemble a tassel of white silk.

The anther is usually round, oval, oblong, or kidney-shaped, and consists of two lobes united by a connective. These

generally open by longitudinal fissure, though sometimes they do so transversely, and at others, as in the case of the heath, they give an outlet to their pollen by pores at their points. Even when the filaments are combined the anthers are distinct from one another, but they are *syngenesious* or united in growth in the sow-thistle (*Sonchus oleraceus*), &c. The pollen is generally shed by introrse openings, *i.e.* those turned inwards towards the pistil; but in some cases, as in the iris, it is shed by extrorse openings, *i.e.* those facing the corolla, and therefore turned outwards. When the base of the anther is firmly fixed in the filament it is *innate;* when attached to it through its whole length, *adnate;* and when only attached by a point on which it swings, *versatile.*

The *gynœcium* is the terminal central organ of flowering plants. It is the female system of the plant, containing the ovules or young seeds, and as the place of greatest safety, occupies the most important part of the flower. It consists of one or more pistils. A delicate small leaf, unlike the petals near it, wraps the seed up in itself. The edges of the two opposite halves of the modified leaf unite and grow together, forming a carpellary (or fruit-containing) leaf, as it does in the plum; and, according to the manner and shape in which it has been folded, taking the form of a pod or of some other vessel. The pistil, thus formed, consists of three parts: (1) the *ovary* or seed-vessel, which is generally surmounted by (2) a hollow tube called the *style*, and this supports a small porous substance like a miniature sponge, naked and not covered by any epidermis, known as (3) the *stigma.* The stigma takes many and various shapes—globular, tufted, feathered, &c., even, as in the case of the *crocus*, showing an orange plume. Though most commonly divided into several lobes (called *stigmata*), it is sometimes even leafy. Its humid and papillose surface is exquisitely fine, and its colour, when viewed through a microscope, often exceedingly rich. That it may fulfil its function properly, it is sticky, so that when any grain of the pollen falls upon or touches it, it may adhere and be absorbed. The young ovary, when cut open, will generally be seen to consist of cells, divided one from another by partitions called *septa* or *dissepiments*, but these often disappear altogether or become imperfectly observable in the ripened state. The ovary may be single-celled, as in the pea and the barberry; or manifold, that is, consisting of two, three, four, five, or many cells, like the water-lily, the harebell, &c.; and these cells may be massed into one body, as in the violet, or be distinct from one another, as in the meadow-sweet. Pistils having carpels distinct from one another are *apocarpous*, united to one another *syncarpous.* Apocarpous pistils receive designations according to the number of their carpels, by prefixing a Greek numeral to the termination *gynous—e.g.* monogynous, digynous, trigynous, &c.

Ordinarily the pistil is hidden in the heart of the flower, carefully concealed by the corolla; but in some cases, as the fuchsia and other pendent flowers, the ovary appears like a swollen, green base, while the pistil is shown conspicuously with the stigma hanging from it like a gem-drop. In some plants, like willow-herbs, many orchids, and some sorts of cactus, however, the ovary, instead of lying in the heart of the flower, is found underneath it, and is then styled *inferior*, as in currant, parsley, &c. It is called *superior* or *free* when it does not adhere to the calyx, as in the primrose (Plate I., fig. 1). Inclosed in the ovary are the *ovules—i.e.* the rudiments of the future seed. They are attached to a development of cellular tissue called the *placenta*, formed in the cavity of the ovary. Out of this the ovules or young seeds arise. *Placentation—i.e.* the manner in which this placental tissue is distributed—is not always the same in all plants, but is always the same in any particular species of plants. In a simple ovary—one formed out of a single carpellary leaf—the placenta is situated on the inner margin of the ovary, that part of it which is called the ventral suture; hence the placentation is called *marginal.* In compound ovaries the kinds of placentation are three—(1) *central* or axillary, in which each of the ovaries is placed in a position similar to that which the ovary occupies when it is simple, and must, of course, therefore be all arranged in the centre, as in the iris; (2) *parietal*, in which the placentas are attached to the side or inner wall of the ovary, or to incomplete *septa*, formed by the folds of the ovaries, as in the poppy; and (3) *free central*, in which the placentas do not adhere to the sides of the ovaries, as in the Arum (fig. 20) and the Bachelor's Button (*Lychnis dioica*).

The interior of the ovary is called the *cell* (Lat. *loculus*). A one-celled ovary is unilocular. As the cells increase in number they are called bilocular, trilocular, and so on, till they become multilocular. The ovary is the covering and protection of the young ovules, the soft, pulpy, germinal matter, which are to be transformed into seeds. When we examine them closely, they seem to consist of two or more skins, inside of which a viscid humour is contained. These skins have an imperceptibly small opening called the *foramen*, through which the pollen makes its way for the fertilization of the seed.

It sometimes happens, as we have said, that between the stamens and the pistils there is interposed either a waxy sort of lining of the calyx, a ring or a cup, scales, glandular tissue, and to this occasional organ, the thalamus of a plant, botanists give the name *disc.* It is seen in the yellowish lining of the plum and cherry, in the cup of the peony, &c. Modern botanists hold the opinion that it indicates a suppressed whorl of stamens. By Bentham and Hooker they are arranged, under the characteristic name of Discifloræ, as one of the divisions of polypetalous plants (see Plate VIII. fig. 3).

In order that the student may have all the help that pictorial illustration can supply in the study of botany, we present several specimens of sections of flowers in Plate VIII., by the careful observation of the separate sections of each of which he may manage to comprehend pretty thoroughly the various parts connected with flowers and the fructification of plants. In this plate fig. 4 is one of the many-flowered umbels of the cherry. The pistil will readily be noticed, rising up as it does from the torus above *c*, where the style and the dotted stigma appear. The stamens are seen with their anther-topped filaments ranged around, and the sepals are spread out like wings in the background. Then fig. 1 is a seedling of the cherry. Fig. 1 *b* shows the embryo-plant taken out of its skin or coat (Lat. *testa*, covering); *c* is the nearer cotyledon, the other being shown behind, in shade; and *r* the radicle or young down-shooting root. Fig. 1 *a* is an apple-seed, of which *c* shows the cotyledons, *t* the testa, *pl* the plumule or young (rising) stem. A section of a buttercup, which is a very easy and convenient flower to begin botanical investigation with, is given in fig. 2, where *r* indicates the *torus, i.e.* the growing point of the flower, and *o* the carpels placed upon it, each containing an ovule. The carpels are the small green bodies of which the pistil is composed; each is conical in shape, with a little pointed head, and there are, in a buttercup, a great (indefinite) number of them—upwards of twenty. The pointed projection is the style, and the lower part which contains the ovule is the ovary. The carpels of the buttercup do not display a stigma. The stamens are marked off by *st; s* indicates the sepals, and *c* the petals of the calyx and corolla respectively. The buttercup has five of each, the former being situated outside of and alternate with the latter. The whole of the four normal whorls are therefore present in the buttercup. It is a complete flower, and having both calyx and corolla it is *dichlamydeous—i.e.* double-cloaked. Had it, like the goosefoot, had no corolla, it would have been *monochlamydeous*, single-cloaked; and if, like the willow, without both of these protecting envelopes, *achlamydeous*, cloakless. We take next, in fig. 3, as a specimen of Disciforæ, one of the geraniales, in which is shown *d*, the disc. In fig. 5 we have an umbelliferous flower, the petals of which are inserted on the outside of an epigynous (fleshy) disc; its stamens are seen incurved; a transverse section of its two-celled (inferior) ovary has been made, and, springing thence, its two distinct styles with simple stigmas are seen. In fig. 6 we have a section of a plant of the order of the Rubiaceæ, of which madder is the type. It shows a monopetalous campanulate corolla, on the tube of which the stamens are inserted. The ovary, which is two-celled, is crowned by a fleshy disc; the style of the pistil is simple, but the stigma is *bifid, i.e.* cleft into two at the top. In 6 *a* a transverse section of the ovary has been

made. The primrose is shown in fig. 7. The ovary, which is presented in section, is a little rounded green body set on the top of the flower-stalk. The short stalk rising from the ovary is the style; the little round head of the style is the stigma. Ovary, style, and stigma constitute the pistil. There is no trace of division into carpels; but it does really consist of five united carpels, and is syncarpous. The heads or anthers of the stamens appear in this flower in the centre of the corolla, and form together a yellow body within it, and are epipetalous. They are not always found so, but may be placed far down in the tube of the corolla. The seed is shown at 7 *a*, and the ripe capsule at 7 *b*. The seeds of the primrose are seated around a central solid body called the placenta, and its placentation is called *free central*. The calyx is *inferior*, the pistil *superior*, and the primrose itself is *dimorphic*, *i.e.* has a flower of two forms, one long-styled, the other short-styled. A specimen of the herbaceous half-shrubby plants, whose flowers are exceedingly variable—the Scrophulariaceæ, of which the foxglove is a member—occurs as fig. 8. The ovary is superior, and may be one or two-celled, the style simple or bifid, the corolla globose or ventricose, monopetalous, and somewhat labiate; fig. 8 *a* is the seed. The funnel-shaped flower of the tobacco plant, which grows in panicles at the top of the stem, shows the sharp pointed down-turned segments of its plaited five-lobed corolla in fig. 9. Its ovary has two cells, each of which has a polyspermatous placenta, and the seed appears as 9 *a*. Goosefoot, with its seed, is given as figs. 10 and 10 *a*. The fine flower of the cinnamon-tree, silky-gray without and pale-yellow inside, displays in section, fig. 11, the cup-like tube of its six segmented calycoidal perianth. Its stamens are seen to be perigynous, inserted on a fleshy disc at the base of the perianth, and appear in multiples of the number of the sepals. They are arranged in four rows, with free filaments, anthers adnate, four-celled; the outer members discharge their pollen introrsely, the inner extrorsely. The carpels are threefold, united into one, the ovary unilocular, the ovule pendent, the style simple, and the stigma trilobed. Its berry is sessile in the perianth-tube. As an illustration of a unisexual flower the Caper-spurge (*Euphorbia lathyrus*) is given in fig. 12. It presents monœcious (Gr. *monos*, one; and *oikos*, a house) male and female naked flowers gathered together into a cup-shaped involucre, resembling a perianth. The female flower, though consisting of an ovary alone, has a triœcious, *i.e.* three-carpelled stalk, and occupies the centre of the involucre. The male flowers, each consisting of a single stamen, are membranous, jointed to the pedicel or stalk, and have a scale at their base. The anthers are two-celled, the stigma is forked. In fig. 13, *a* is the male flower, *b* the female flower, and *c* the ripe capsule of the willow. The willow flowers into a unisexual spike called a catkin, which falls away on fruiting. The stamens and pistils appear on different individuals, and their dry powdery pollen is wind-wafted or bee-borne from the anthers of the male to the hair-covered stigmas of the female plants. The stamens, as in *a*, are distinct or monodelphous; the pistil *b*, a one-celled follicle with a gland and its base; and *c*, the comate (*i.e.* hair-tufted) seed, furnished for locomotion by wind-transport or insect-carriage.

The four whorls which we have just been illustrating are generally regarded as the characteristic parts of flowering plants, but as the whole four are not found in all, an endeavour has been made to arrange them in classes with reference to these characteristics. The following tabular view will present briefly this classification, and the distinctions which mark each class, with examples:—

Flowers are	I. Complete,	(1) Thalamifloræ—having stamens and pistils in the receptacle.	Buttercup, mallow, violet, chickweed, &c.
		(2) Calycifloræ—having stamens and pistils in the calyx.	Rose, bean, celery, &c.
		(3) Corollifloræ, gamopetalous—having united petals.	Daisy, heath, primrose, harebell, foxglove, &c.
	II. Incomplete,	. . Apetalæ—without petals or corolla.	Elm, fir, oak, &c.

The distinct parts of the flowers of plants are

I. Enveloping and Protective.

Perianth.

1. Calyx.	2. Corolla.
(1) Gamosepalous.	(1) Gamopetalous or sympetalous.
(2) Polysepalous.	(2) Polypetalous or apopetalous.

II. Essential and Reproductive.

Thalamus.

1. *Andrœcium*, containing—	2. *Gynœcium*, containing—
(1) Stamens: (*a*) hypogynous; (*b*) perigynous.	(1) Pistils: (*a*) syncarpous; (*b*) apocarpous.
(2) Filament.	(2) Ovary: (*a*) simple; (*b*) compound.
(3) Anther: (*a*) introrse; (*b*) extrorse.	(3) Style: (*a*) monodelphous; (*b*) didelphous; (*c*) polyadelphous.
	(4) Stigma.

THE GERMAN LANGUAGE.—CHAPTER IX.

Language does not issue from a mint ready-made by grammarians. All its issues are not cast in the same mould, nor are all words, like coins, marked once and for ever with the same form and significance. It is the outcome of minds having similar powers, excited by similar desires, and yet, not unfrequently, placed in different circumstances and brought under the influence of varying associations. Hence all languages exhibit in their inner structure considerable general sameness, and yet show a number of singular differences. The grammarian does not preside over the birth of language. When he assumes to be the guide, corrector, and instructor language has developed many of its most characteristic qualities. The habitual phraseology of tribes and people has settled into forms and usages. These the grammarian examines, classifies, perhaps criticises and accounts for, and then fixes into statements, which he presents as rules and recommends as the laws of speech. The phenomena of vital activity are seldom entirely consistently uniform, nor do they always conform to the regulations which grammarians would fix and settle as their governing principles. All forms of phraseology which vary from common grammatical rules are by these expositors of principles regarded as irregularities and exceptions. This, as phenomena, of course they are; but they have their origin always in some vital fact in the logic of thought or in the history of a race. In the old German grammars long and tedious lists of variously conjugated verbs were accumulated and set down as irregular, and this continued to be laid as a heavy load on the student's memory, without attempt at explanation, until the philological researches of Grimm, Humboldt, Becker, &c., showed that these had a principle of life of their own, and verbs were divided into the new classification of ancient, radical, primitive, or strong, and modern, derivative, or weak verbs—the former expressing almost all the chief activities of life and nature, and therefore almost all imitative in some suggestive way, and the latter those abstract and philosophically discriminated terms which have been found necessary in the progress of culture and civilization. It will be found that both the mixed and the irregular or strong verbs have laws regulating their conjugation, quite as constant in their own way

as those which have been trained and tended by grammatical care till they have become known as weak.

In last lesson the pupil learned that German verbs can be most conveniently divided into three conjugations, regular, mixed, and irregular, and he should have mastered the conjugation of the three model forms given—lieben, kennen, and singen.

The first or regular conjugation presents little difficulty. The vowel of the root-syllable is never modified or changed, the imperfect tense always ends in -te, and the past participle is always formed by placing ge- before the root-syllable and -t after it; as suchen, to seek; ich suchte, I sought; gesucht, sought. Among the numerous verbs conjugated in this way are all verbs whose root-vowels are o, u, or eu; all those whose root-vowel is modified, as ä, ö, ü, or äu; and almost all those ending in zen, cken, chten, gnen, eln, ern, igen, iren, and ieren.

The second or mixed conjugation does not contain many verbs; they all have the imperfect tense and the past participle *terminating* in the same way as regular verbs, but they *change the vowel of the root-syllable* in these parts, and two of them, bringen and denken, change some of their consonants also. The following is a list of these verbs:—

INFINITIVE.	IMPERFECT.	PAST PARTICIPLE.	
Brennen,	brannte,	gebrannt,	to burn.
kennen,	kannte,	gekannt,	to know.
nennen,	nannte,	genannt,	to name.
rennen,	rannte,	gerannt,	to run.
senden,	sandte,	gesandt,	to send.
wenden,	wandte,	gewandt,	to turn.
bringen,	brachte,	gebracht,	to bring.
denken,	dachte,	gedacht,	to think.
wissen,	wußte,	gewußt,	to know.

Observe that bringen and denken make brachte and dachte in the imperfect tense. The present tense of wissen is Ich weiß, du weißt, er weiß; wir wissen, Sie wissen, sie wissen.

The third or irregular conjugation contains about one hundred and sixty verbs, and is one of the great stumbling-blocks to the young student of German, although with a proper method and a fair amount of perseverance no great difficulty should be experienced in mastering them. At first it is simply a question of memory. The student must learn the conjugation of each group of verbs, so that by looking at the English he can at once give the parts of the verb printed opposite it, and then he will be surprised how soon his ear will begin to assist him, and he will know at once from the sound when a verb is incorrectly conjugated. Above all things too much must not be attempted at once—only one, or at most two, groups of verbs in the same day or evening.

Verbs of this conjugation may, with great advantage to the memory, be arranged in three classes, according to the changes they undergo in the root-vowels of the three important parts—the present infinitive, imperfect indicative, and past participle. In one class the vowels are different in each of these parts, in another those of the infinitive and the participle are the same, and in the third those of the imperfect and the participle are the same.

The imperfect subjunctive of these verbs is formed by adding e to the imperfect indicative, and modifying the root-vowel if it is a, o, or u: thus finden, to find; imperfect, Ich fand, I found; imperfect subjunctive, Ich fände, du fändest, er fände, wir fänden, &c.

IRREGULAR VERBS—First Class.

In this class the root-vowels are different in each of the three chief parts. These verbs can best be learned in three sections.

I. Those which have i in the infinitive take i in the present, a in the imperfect indicative (modified in the subjunctive to ä), and u in the past participle, as under:—

INFINITIVE.	IMPERFECT.	PAST PARTICIPLE.	
Binden,	band,	gebunden,	to bind.
dringen,	drang,	gedrungen,	to penetrate.
finden,	fand,	gefunden,	to find.
ge-lingen,	gelang,	gelungen,	to succeed.
klingen,	klang,	geklungen,	to sound.
ringen,	rang,	gerungen,	to wring.
schlingen,	schlang,	geschlungen,	to sting.
schwinden,	schwand,	geschwunden,	to dwindle.
schwingen,	schwang,	geschwungen,	to swing.
singen,	sang,	gesungen,	to sing.
sinken,	sank,	gesunken,	to sink.
springen,	sprang,	gesprungen,	to spring.
stinken,	stank,	gestunken,	to stink.
trinken,	trank,	getrunken,	to drink.
winden,	wand,	gewunden,	to wind.
zwingen,	zwang,	gezwungen,	to force.

EXCEPTIONS.—Dingen, to bargain, schinden, to flay, take u in the imperfect indicative, ü in the imperfect subjunctive, and u in the past participle. Klingen is regular in the signification to tinkle.

II. Those which have i in the infinitive take i in the present, a in the imperfect indicative (modified ordinarily in the imperfect subjunctive into ö, yet sometimes taking the regular ä), and in the past participle o, as under:—

INFIN.	IMPERF.	PAST PART.	
Beginnen,	begann,	begonnen,	to begin.
ge-winnen,	gewann,	gewonnen,	to win, gain.
rinnen,	rann,	geronnen,	to run.
schwimmen,	schwamm,	geschwommen,	to swim.
sinnen,	sann,	gesonnen,	to meditate.
spinnen,	spann,	gesponnen,	to spin.

III. Those which have e or ä in the infinitive take i or ie, a or o in the imperfect indicative (modified into ä or ö in the subjunctive), and o in the past participle, as under.

The four verbs marked with an asterisk (*) change the root-vowel into ie in the second and third persons of the present indicative; thus Ich befehle, du befiehlst, er befiehlt, wir befehlen, &c., du gebierst, du stiehlst. All the other verbs change the e of the root into i, as Ich berge, du birgst, er birgt, wir bergen, &c.; but bersten is *regular*, making du berstest, er berstet, and nehmen makes du nimmst, er nimmt.

INFIN.	IMPERF.	PAST PART.	
Bergen,	barg,	geborgen,	to hide.
brechen,	brach,	gebrochen,	to break.
erschrecken,	erschrak,	erschrocken,	to startle.
gelten,	galt,	gegolten,	to be worth.
helfen,	half,	geholfen,	to help.
schelten,	schalt,	gescholten,	to chide.
sprechen,	sprach,	gesprochen,	to speak.
stechen,	stach,	gestochen,	to sting.
sterben,	starb,	gestorben,	to die.
treffen,	traf,	getroffen,	to hit.
ver-derben,	verdarb,	verdorben,	to spoil.
werben,	warb,	geworben,	to woo, sue.
werfen,	warf,	geworfen,	to throw.
*be-fehlen,	befahl,	befohlen,	to order.
*emp-fehlen,	empfahl,	empfohlen,	to recommend.
*ge-bären,	gebar,	geboren,	to bear.
*stehlen,	stahl,	gestohlen,	to steal.
bersten,	barst,	geborsten,	to burst.
nehmen,	nahm,	genommen,	to take.
dreschen,	drosch,	gedroschen,	to thresh.
stehen,	stand,	gestanden,	to stand.

IRREGULAR VERBS—Second Class.

The second class comprises also three divisions, viz.—

I. Those which have e or i in the infinitive take i in the present, a in the imperfect indicative (modified into ä in the subjunctive), and e in the past participle, as under.

These verbs change the vowel e of the root-syllable into i in the second and third persons of the present indicative, as Ich esse, du issest, er ißt, wir essen, &c.; but the two verbs marked with an asterisk change the e into ie, as es geschiet, it happens; du siehst, thou seest. Genesen is *regular* in the present tense, and makes du genesest, er geneset.

INFIN.	IMPERF.	PAST PART.	
Essen,	aß,	gegessen,	to eat.
fressen,	fraß,	gefressen,	to devour.
geben,	gab,	gegeben,	to give.

INFIN.	IMPERF.	PAST PART.	
leſen,	las,	geleſen,	to read.
meſſen,	maß,	gemeſſen,	to measure.
ſtecken,	ſtak,	geſteckt,	to stick.
treten,	trat,	getreten,	to step.
vergeſſen,	vergaß,	vergeſſen,	to forget.
*ſehen,	ſah,	geſehen,	to see.
*ge=ſchehen,	geſchah,	geſchehen,	to happen.
ge=neſen,	genas,	geneſen,	to recover.

The three following are the only instances in which the i of the infinitive, the first person of the present indicative, and the second of the imperative have been preserved:—

INFIN.	IMPERF.	PAST PART.	
bitten,	bat,	gebeten,	to request.
liegen,	lag,	gelegen,	to lie (extended).
ſitzen,	ſaß,	geſeſſen,	to sit.

II. Those which have a in the infinitive take the modified ä in the second and third persons singular of the present indicative, as du bäckſt, er bäckt, wir backen; u in the imperfect indicative (modified into ü in the subjunctive), and a in the past participle, as under. Schaffen is regular in the present indicative, making du ſchaffeſt, er ſchafft.

INFIN.	IMPERF.	PAST PART.	
Backen,	buk,	gebacken,	to bake.
fahren,	fuhr,	gefahren,	to go (be conveyed).
graben,	grub,	gegraben,	to dig.
laden,	lud,	geladen,	to load.
mahlen,	regular,	gemahlen,	to paint.
ſchlagen,	ſchlug,	geſchlagen,	to beat.
tragen,	trug,	getragen,	to carry.
wachſen,	wuchs,	gewachſen,	to grow.
waſchen,	wuſch,	gewaſchen,	to wash.
ſchaffen,	ſchuf,	geſchaffen,	to create.

III. Those which have a (au, u, o) in the infinitive take ä in the second and third persons singular of the present indicative, ie or i in the imperfect indicative (and subjunctive), and a (au, u, o) in the past participle, as under:—

INFIN.	IMPERF.	PAST PART.	
Blaſen,	blies,	geblaſen,	to blow.
braten,	briet,	gebraten,	to roast.
fallen,	fiel,	gefallen,	to fall.
falten,	regular,	gefalten,	to plait.
fangen,	fing,	gefangen,	to catch.
halten,	hielt,	gehalten,	to hold.
hangen,	hing,	gehangen,	to hang, depend.
laſſen,	ließ,	gelaſſen,	to let, allow.
rathen,	rieth,	gerathen,	to advise.
ſalzen,	regular,	geſalzen,	to salt.
ſchlafen,	ſchlief,	geſchlafen,	to sleep.
ſpalten,	regular,	geſpalten,	to cleave.
ſchmalzen,	regular,	geſchmalzen,	to lard.

The following six verbs alone have the vowels indicated in the parentheses: they all follow the *regular* verbs in their mode of forming the present indicative, as du kommſt, er kommt; but laufen and ſtoßen modify the root-vowel in the second and third persons singular of this tense, as du läufſt, er ſtößt.

INFIN.	IMPERF.	PAST PART.	
Hauen,	hieb,	gehauen,	to hew.
kommen,	kam,	gekommen,	to come.
rufen,	rief,	gerufen,	to call.
ſchroten,	regular,	geſchroten,	to bruise.
laufen,	lief,	gelaufen,	to run.
ſtoßen,	ſtieß,	geſtoßen,	to thrust.
thun,	that,	gethan,	to do.

IRREGULAR VERBS—Third Class.

This class may also be arranged in three divisions, viz.—

I. Those which have ei for the radical vowel of the infinitive take in some cases i and in others ie in the imperfect and in the past participle, as under. These verbs are *regular* in the present indicative, as Ich beiße, du beißeſt, er beißt, &c.

INFIN.	IMPERF.	PAST PART.	
Be=fleißen,	befliß,	befliſſen,	to apply.
beißen,	biß,	gebiſſen,	to bite.
bleichen,	blich,	geblichen,	to bleach.
gleichen	glich,	geglichen,	to resemble.
gleiten,	glitt,	geglitten,	to slip.
greifen,	griff,	gegriffen,	to seize.
keifen,	kiff,	gekiffen,	to scold.
kneifen *or* kneipen,	kniff *or* knipp,	gekniffen *or* geknippen,	to pinch, nip.
leiden,	litt,	gelitten,	to suffer.
pfeifen,	pfiff,	gepfiffen,	to whistle.
reißen,	riß,	geriſſen,	to tear.
reiten,	ritt,	geritten,	to ride.
ſchleichen,	ſchlich,	geſchlichen,	to sneak.
ſchleifen,	ſchliff,	geſchliffen,	to sharpen.
ſchleißen,	ſchliß,	geſchliſſen,	to slit.
ſchmeißen,	ſchmiß,	geſchmiſſen,	to smite.
ſchneiden,	ſchnitt,	geſchnitten,	to cut.
ſchreiten,	ſchritt,	geſchritten,	to stride.
ſpleißen,	ſpliß,	geſpliſſen,	to split.
ſtreichen,	ſtrich,	geſtrichen,	to strike.
ſtreiten,	ſtritt,	geſtritten,	to dispute.
weichen,	wich,	gewichen,	to yield.

Bleiben,	blieb,	geblieben,	to remain.
ge=deihen,	gedieh,	gediehen,	to prosper.
heißen,	hieß,	geheißen,	to be named.
leihen,	lieh,	geliehen,	to lend.
meiden,	mied,	gemieden,	to avoid.
preiſen,	pries,	geprieſen,	to praise.
reiben,	rieb,	gerieben,	to rub.
ſcheiden,	ſchied,	geſchieden,	to separate.
ſcheinen,	ſchien,	geſchienen,	to shine, appear.
ſchreiben,	ſchrieb,	geſchrieben,	to write.
ſchreien,	ſchrie,	geſchrieen,	to cry.
ſchweigen,	ſchwieg,	geſchwiegen,	to be silent.
ſpeien,	ſpie,	geſpieen,	to spit.
ſteigen,	ſtieg,	geſtiegen,	to ascend.
treiben,	trieb,	getrieben,	to drive.
weiſen,	wies,	gewieſen,	to show.
zeihen,	zieh,	geziehen,	to accuse.

II. Those which have ie or ü in the infinitive retain them in the present—except in some poetic forms (having eu, always long), which ought not to be used (unless very exceptionally) in prose—and take in the imperfect indicative o (modified into ö in subjunctive), and in the past participle also o, as under. These verbs form their present indicative in the regular way.

INFIN.	IMPERF.	PAST PART.	
Biegen,	bog,	gebogen,	to bend.
bieten,	bot,	geboten,	to offer.
fliegen,	flog,	geflogen,	to fly.
fliehen,	floh,	geflohen,	to flee.
fließen,	floß,	gefloſſen,	to flow.
frieren,	fror,	gefroren,	to freeze.
ge=nießen,	genoß,	genoſſen,	to enjoy.
gießen,	goß,	gegoſſen,	to pour.
kriechen,	kroch,	gekrochen,	to creep.
küren,	kor,	gekoren,	to choose.
lügen,	log,	gelogen,	to lie, speak falsely.
riechen,	roch,	gerochen,	to smell.
ſchieben,	ſchob,	geſchoben,	to push.
ſchießen,	ſchoß,	geſchoſſen,	to shoot.
ſchließen,	ſchloß,	geſchloſſen,	to close.
ſieden,	ſott,	geſotten,	to seethe, boil.
ſprießen,	ſproß,	geſproſſen,	to bud.
ſtieben,	ſtob,	geſtoben,	to dust.
triefen,	troff,	getroffen,	to drip.
trügen (triegen),	trog,	getrogen,	to trick.
ver=drießen,	verdroß,	verdroſſen,	to grieve, offend.
ver=lieren,	verlor,	verloren,	to lose.
wiegen,	wog,	gewogen,	to weigh.
ziehen,	zog,	gezogen,	to pull.

The following verbs have au in the infinitive: saufen alone modifies the radical vowels in the present indicative, as du säufest, er säuft, wir saufen.

INFIN.	IMPERF.	PAST PART.	
Saugen,	sog,	gesogen,	to suck.
schnauben,	schnob,	geschnoben,	to snort.
schrauben,	schrob,	geschroben,	to screw.
saufen,	soff,	gesoffen,	to drink.

III. Those which have in their infinitives the radical vowels i, e, ä, ö, and a, belonging primarily to different other classes, take o in their imperfects and in their past participles, as under:—

INFIN.	IMPERF.	PAST PART.	
Glimmen,	glomm,	geglommen,	to glitter.
klimmen,	klomm,	geklommen,	to climb.
be=wegen,	bewog,	bewogen,	to determine.
heben,	hob,	gehoben,	to lift.
pflegen,	pflog,	gepflogen,	to foster.
quellen,	quoll,	gequollen,	to spring.
weben,	wob,	gewoben,	to weave.
gähren,	gohr,	gegohren,	to ferment.
wiegen,	wog,	gewogen,	to weigh.
schwören,	schwor (schwur),	geschworen,	to swear.
schallen,	scholl,	geschollen,	to shell, peel.

The following verbs are conjugated like the above, except that they do not form the present indicative in the regular way. They change the radical vowel e into i in the second and third persons singular. Scheren makes du schierst, er schiert.

Fechten,	focht,	gefochten,	to fight.
flechten,	flocht,	geflochten,	to plait.
melken,	molk,	gemolken,	to milk.
schmelzen,	schmolz,	geschmolzen,	to melt.
schwellen,	schwoll,	geschwollen,	to swell.
löschen,	losch,	geloschen,	to extinguish.
scheren,	schor,	geschoren,	to shear.

In the preceding sections we have presented the irregular verbs arranged in groups, so as to facilitate the committal of them to memory. We shall now proceed to give these verbs arranged in alphabetical order for future reference. In subsequent lessons, when the student has any doubt about the conjugation of a verb, let him turn to the following list; if he does not find in it the verb he seeks he may presume it to be regular; if he does find it, the reference figures placed before it will tell him where to turn for any further information he requires. The first figures (1, 2, 3) represent the class to which the verb belongs, while the numerals (I., II., III.) show the special section of the class in which it will be found.

Alphabetical List of Irregular Verbs.

2. II. Backen, buk, gebacken, to bake.
1. III. befehlen, befahl, befohlen, to command.
3. I. befleißen, befliß, beflissen, to apply.
1. II. beginnen, begann, begonnen, to begin.
3. I. beißen, biß, gebissen, to bite.
1. III. bergen, barg, geborgen, to conceal.
1. III. bersten, barst, geborsten, to burst.
3. III. bewegen, bewog, bewogen, to move.
3. II. biegen, bog, gebogen, to bend.
3. II. bieten, bot, geboten, to bid, offer.
1. I. binden, band, gebunden, to bind.
2. I. bitten, bat, gebeten, to beg.
2. III. blasen, blies, geblasen, to blow.
3. I. bleiben, blieb, geblieben, to remain.
3. I. bleichen, blich, geblichen, to bleach.
2. III. braten, briet, gebraten, to roast.
1. III. brechen, brach, gebrochen, to break.
3. I. dingen, dung, gedungen, to bargain.
1. III. dreschen, drosch, gedroschen, to thrash.
1. I. dringen, drang, gedrungen, to press.
1. III. empfehlen, empfahl, empfohlen, to recommend.
1. III. erschrecken, erschrak, erschrocken, to be frightened.
2. I. essen, aß, gegessen, to eat.
2. II. fahren, fuhr, gefahren, to drive.
2. III. fallen, fiel, gefallen, to fall.
2. III. falten, faltete, gefalten, to fold.
2. III. fangen, fing, gefangen, to catch.
3. III. fechten, focht, gefochten, to fight.
1. I. finden, fand, gefunden, to find.
3. III. flechten, flocht, geflochten, to twist, plait.
3. II. fliegen, flog, geflogen, to fly.
3. II. fliehen, floh, geflohen, to flee.
3. II. fließen, floß, geflossen, to flow.
2. I. fressen, fraß, gefressen, to devour.
3. II. frieren, fror, gefroren, to freeze.
3. III. gähren, gohr, gegohren, to ferment.
1. III. gebären, gebar, geboren, to bring forth.
2. I. geben, gab, gegeben, to give.
3. I. gedeihen, gedieh, gediehen, to prosper.
2. I. gehen, ging, gegangen, to go.
1. I. gelingen, gelang, gelungen, to succeed.
1. III. gelten, galt, gegolten, to be worth.
2. I. genesen, genas, genesen, to recover.
3. II. genießen, genoß, genossen, to enjoy.
2. I. geschehen, geschah, geschehen, to happen.
1. II. gewinnen, gewann, gewonnen, to gain.
3. II. gießen, goß, gegossen, to pour.
3. I. gleichen, glich, geglichen, to resemble.
3. I. gleiten, glitt, geglitten, to glide.
3. III. glimmen, glomm, geglommen, to glimmer.
2. II. graben, grub, gegraben, to dig.
3. I. greifen, griff, gegriffen, to seize.
2. III. halten, hielt, gehalten, to hold.
2. III. hangen, hing, gehangen, to hang.
2. III. hauen, hieb, gehauen, to cut, hew.
3. III. heben, hub, gehoben, to lift.
3. I. heißen, hieß, geheißen, to be named.
1. III. helfen, half, geholfen, to help.
3. I. keissen, kiss, gekissen, to scold.
3. III. klimmen, klomm, geklommen, to climb.
1. I. klingen, klang, geklungen, to sound.
3. I. kneifen, kniff, gekniffen, to pinch.
2. III. kommen, kam, gekommen, to come.
3. II. kriechen, kroch, gekrochen, to creep.
3. II. küren, kor, gekoren, to choose.
2. II. laden, lud, geladen, to load.
2. III. lassen, ließ, gelassen, to let.
2. III. laufen, lief, gelaufen, to run.
3. I. leiden, litt, gelitten, to suffer.
3. I. leihen, lieh, geliehen, to lend.
2. I. lesen, las, gelesen, to read.
2. I. liegen, lag, gelegen, to lie.
3. III. löschen, losch, geloschen, to go out.
3. II. lügen, log, gelogen, to tell a falsehood.
2. II. mahlen, mahlte, gemahlen, to grind.
3. I. meiden, mied, gemieden, to avoid.
3. III. melken, molk, gemolken, to milk.
2. I. messen, maß, gemessen, to measure.
1. III. nehmen, nahm, genommen, to take.
3. I. pfeifen, pfiff, gepfeiffen, to whistle.
3. III. pflegen, pflog, gepflogen, to practise, cherish.
3. I. preisen, pries, gepriesen, to praise.
3. III. quellen, quoll, gequollen, to spring.
2. III. rathen, rieth, gerathen, to advise.
3. I. reiben, rieb, gerieben, to rub.
3. I. reißen, riß, gerissen, to tear.
3. I. reiten, ritt, geritten, to ride.
3. II. riechen, roch, gerochen, to smell.
1. I. ringen, rang, gerungen, to wrestle.
1. II. rinnen, rann, geronnen, to run, leak.
2. III. rufen, rief, gerufen, to call.
2. III. salzen, regular, gesalzen, to salt.
3. II. saufen, soff, gesoffen, to drink (said of beasts).
3. II. saugen, sog, gesogen, to suck.
2. II. schaffen, schuf, geschaffen, to create.
3. III. schallen, scholl, geschollen, to peel.
3. I. scheiden, schied, geschieden, to part.
3. I. scheinen, schien, geschienen, to shine.

1\. III. ſchelten, ſchalt, geſcholten, to scold.
3\. III. ſcheren, ſchor, geſchoren, to shear.
3\. II. ſchieben, ſchob, geſchoben, to shove.
3\. II. ſchießen, ſchoß, geſchoſſen, to shoot.
3\. I. ſchinden, ſchund, geſchunden, to flay.
2\. III. ſchlafen, ſchlief, geſchlafen, to sleep.
2\. II. ſchlagen, ſchlug, geſchlagen, to beat, strike.
3\. I. ſchleichen, ſchlich, geſchlichen, to sneak.
3\. I. ſchleifen, ſchliff, geſchliffen, to sharpen.
3\. I. ſchleißen, ſchliß, geſchliſſen, to slit.
3\. II. ſchließen, ſchloß, geſchloſſen, to shut, lock, conclude.
1\. I. ſchlingen, ſchlang, geſchlungen, to sling, twist.
2\. III. ſchmalzen, ſchmalzte, geſchmalzen, to lard.
3\. I. ſchmeißen, ſchmißi, geſchmiſſen, to fling.
3\. III. ſchmelzen, ſchmolz, geſchmolzen, to melt.
3\. II. ſchnauben, ſchnob, geſchnoben, to snort.
3\. I. ſchneiden, ſchnitt, geſchnitten, to cut.
3\. II. ſchrauben, ſchrob, geſchroben, to screw.
3\. I. ſchreiben, ſchrieb, geſchrieben, to write.
3\. I. ſchreien, ſchrie, geſchrieen, to cry.
3\. I. ſchreiten, ſchritt, geſchritten, to stride.
2\. III. ſchroten, ſchrotete, geſchroten, to bruise.
3\. I. ſchweigen, ſchwieg, geſchwiegen, to be silent.
3\. III. ſchwellen, ſchwoll, geſchwollen, to swell.
1\. II. ſchwimmen, ſchwamm, geſchwommen, to swim.
1\. I. ſchwinden, ſchwand, geſchwunden, to vanish.
1\. I. ſchwingen, ſchwang, geſchwungen, to swing.
3\. III. ſchwören, ſchwur, geſchworen, to swear.
2\. I. ſehen, ſah, geſehen, to see.
3\. II. ſieden, ſott, geſotten, to boil.
1\. I. ſingen, ſang, geſungen, to sing.
1\. I. ſinken, ſank, geſunken, to sink.
1\. II. ſinnen, ſann, geſonnen, to meditate.
2\. I. ſitzen, ſaß, geſeſſen, to sit.
2\. III. ſpalten, ſpaltete, geſpalten, to cleave.
3\. I. ſpeien, ſpie, geſpieen, to spit.
1\. II. ſpinnen, ſpann, geſponnen, to spin.
3\. I. ſpleißen, ſpliß, geſpliſſen, to split.
1\. III. ſprechen, ſprach, geſprochen, to speak.
3\. II. ſprießen, ſproß, geſproſſen, to sprout.
1\. I. ſpringen, ſprang, geſprungen, to spring.
1\. III. ſtechen, ſtach, geſtochen, to sting.
2\. I. ſtecken, ſtak, geſteckt, to stick.
1\. III. ſtehen, ſtand, geſtanden, to stand.
1\. III. ſtehlen, ſtahl, geſtohlen, to steal.
3\. I. ſteigen, ſtieg, geſtiegen, to mount.
1\. III. ſterben, ſtarb, geſtorben, to die.
3\. II. ſtieben, ſtob, geſtoben, to scatter.
1\. I. ſtinken, ſtank, geſtunken, to smell ill.
2\. III. ſtoßen, ſtieß, geſtoßen, to push.
3\. I. ſtreichen, ſtrich, geſtrichen, to stroke.
3\. I. ſtreiten, ſtritt, geſtritten, to strive.
2\. III. thun, that, gethan, to do.
2\. II. tragen, trug, getragen, to carry.
1\. III. treffen, traf, getroffen, to hit.
3\. I. treiben, trieb, getrieben, to drive.
2\. I. treten, trat, getreten, to tread.
3\. II. triefen, troff, getroffen, to drip.
1\. I. trinken, trank, getrunken, to drink.
3\. II. trügen, trog, getrogen, to deceive.
1\. III. verderben, verdarb, verdorben, to corrupt, decay.
3\. II. verdrießen, verdroß, verdroſſen, to grieve, vex.
2\. I. vergeſſen, vergaß, vergeſſen, to forget.
3\. II. verlieren, verlor, verloren, to lose.
2\. II. wachſen, wuchs, gewachſen, to grow.
2\. II. waſchen, wuſch, gewaſchen, to wash.
3\. III. wägen, wog, gewogen, to weigh.
3\. III. weben, wob, gewoben, to weave.
3\. I. weichen, wich, gewichen, to yield.
3\. I. weiſen, wies, gewieſen, to show.
1\. III. werben, warb, geworben, to enlist, sue for.
1\. III. werfen, warf, geworfen, to throw.
3\. II. wiegen, wog, gewogen, to weigh.
1\. I. winden, wand, gewunden, to wind.
3\. I. zeihen, zieh, geziehen, to accuse of.
3\. II. ziehen, zog, gezogen, to draw, pull.
1\. I. zwingen, zwang, gezwungen, to compel.

EXERCISES.

Give the German for—

CLASS I. I bind. They have bound. He succeeded. It sounded. She sang. He began. They have won. She ran. It breaks. He helped. They have spoken. I threw. She ordered. He steals. They have taken.

CLASS II. He eats. We have eaten. She gave. They have forgotten. Thou seest. She bakes. He carried. It grows. They have washed. It blows. He fell. They are caught. He slept. I came. He called. It is done.

CLASS III. It has bitten. She suffered. It is cut. He yielded. It remained. They are separated. He cried. They have driven. It bent. It is frozen. He shot. She is offended. We have lost. He drinks. I climbed. He lifted. It sprang. They have woven. They weighed it. They have fought. It is plaited. It melted.

ENGLISH GRAMMAR AND COMPOSITION.

CHAPTER VII.

IRREGULAR VERBS—MIXED CONJUGATIONS—RULES FOR USING THEM—DEFECTIVE VERBS.

LOGIC regulates speech and settles for, or at least among, investigators the manner in which language, to be accurate and intelligible, ought to be used. But higher influences and causes, over which theoretical logic has no control, have governed the historical development of our modes of speech, and a due submission to the logic of facts forbids us lightly to reduce forms of expression, consecrated by age and inspired by that love of independence which characterized our forefathers, into stricter shapes and more formal, even if more normal, modes of utterance. While endeavouring to make our language the best possible organ for the communication of thought, we should reverence the living power of our speech, in which it shows the history of our nation impressed upon it almost as distinctly as the phenomena of geology indicate the revolutions which have taken place in the condition of the earth. Our strong verbs are the most expressive, the most closely related to real life and emotion, and the most simple and characteristic in the language; and therefore a knowledge of their forms and uses, and a careful attention to their peculiarities, is important to all those who would employ language so as to be at once most intelligible and most impressive.

Many strong verbs, clearly belonging to the old Teutonic vocabulary, to which our language has been so much indebted for suggestive expressiveness, have now become obsolete or have taken the weak form, in compliance with custom and the greater convenience of regularity—*e.g.* (1) grave, shave, shape, lade, &c., of which the strong participle is yet occasionally found in use; (2) fold, walk, low, row, span, leap, &c., which now only appear in provincial dialects and in poetical usages in other than in weak forms. Among those which have completely parted with their old strong forms we may note—bellow, burn, burst, carve, delve, ding, melt, milk, mourn, spurn, starve, stint, swallow, yield, &c.; yet in our old authors we have *brast* (Sackville), *dalve* (Pilkington), *malt* (Capgrave), *yielden* (Surrey). *Swollen* has now almost given place to *swelled*, and *helped* has supplanted both *holp* and *holpen*. Nowadays ache, bake, creep, fare, gnaw, laugh, step, wade, wash, wax, yell, take no longer such pasts as oke, book, crope, foerde, gnew, loffe, stap, wode, wesh, wox, yoll. In the same way *drive* and *strive* no longer use *drave* and *strave*, or *strike*, *strake*, *chide*, *chade*, &c. In the reading of our early writers many similar forms of strong inflexions will meet and puzzle those who have only a knowledge of the present modern usages of our language. These old-fashioned, obsolete, and obsolescent words, however, have frequently a great charm and an expressiveness which are not to be found in their modern equivalents. But as we have parted with them in our endeavour after a refinement which seeks uniformity, we may not recover them, and need not incorporate them in such lessons as we are giving—which are not intended to be either antiquarian or curious, but to be simple and immediately useful. Still we may observe that in a great many cases these old verbs resembled the strong verbs of the Germans, and it might be of some use for English students to refer to

the German strong verbs, and for German ones to note how many of these are to be found in daily use among ourselves.

Having already treated pretty fully of strong verbs, we shall now proceed to consider those whose conjugation-forms have got only somewhat weakened, and may therefore be conveniently classified as mixed.

Mixed Verbs.—In some cases a compromise has, as it were, been come to between the strong and the weak verbs, and the verb-flexions are managed by a combination of internal vowel change and external addition—the past participle taking the new formation-affix *d* or *ed*, which admits of being contracted into *t*, but involves not unfrequently changes of spelling arising from the demands of euphony. Of these we may quote the following:—

(1) Which shorten the vowel and add *d* or *t*.

Bereave	bereft	bereft.	Lose	lost	lost.
Cleave	cleft	cleft.	Read	read	read.
Creep	crept	crept.	Shoe	shod	shod.
Dwell	dwelt	dwelt.	Shoot	shot	shot.
Feel	felt	felt.	Sleep	slept	slept.
Flee	fled	fled.	Smell	smelt	smelt.
Keep	kept	kept.	Sweep	swept	swept.
Lead	led	led.	Weep	wept	wept.
Leave	left	left.			

The contraction of *ed* by the elision of *e* leaves *d*, not *t*, remaining; but custom has sanctioned the employment in some words like feel, felt; smell, smelt; creep, crept, &c., of a contracted or rather a substituted form in *t*. This *t*-sound, however, is curt, wiry, and harsh, and is, when preceded by a mute, exceedingly disagreeable in articulation, and any such contractions as *movt*, *provt*, *grazt*, *praist*, *killt*, &c., offending as they do against euphony, are advisably not used.

(2) Which either simply (*a*) add *d* or *t*, or (*b*) change the terminal *d* to *t*.

(*a*)	Burn	burnt	burnt.	Leap	leapt	leapt.
	Deal	dealt	dealt.	Learn	learnt	learnt.
	Dream	dreamt	dreamt.	Mean	meant	meant.
	Hear	heard	heard			
(*b*)	Bend	bent	bent.	Lend	lent	lent.
	Blend	blent	blent.	Rend	rent	rent.
	Build	built	built.	Send	sent	sent.
	Gild	gilt	gilt.	Spend	spent	spent.
	Gird	girt	girt.	Spill	spilt	spilt.

(3) Which have adopted the weak *d* or *ed* in the past, but retain the strong *n* or *en* in the participle:—

Bake	baked	baken.	Rive	rived	riven.
Grave	graved	graven.	Shape	shaped	shapen.
Hew	hewed	hewn.	Shave	shaved	shaven.
Lade	laded	laden.	Show	showed	shown.
Mow	mowed	mown.	Strew	strewed	strewn.

(4) Those which orthographically change *y* into *i* before adding *d*.

Lay	laid	laid.	Pay	paid	paid.
Say	said	said.			

(5) The fifth class have the *ee* of the present contracted into *e* in the past and past participle:—

Bleed	bled	bled	Feed	fed	fed.
Breed	bred	bred	Meet	met	met.
Speed	sped	sped.			

(6) The following verbs may be gathered together into one class, though certain differences will require remark:—

Beseech	besought	besought.	Reach	reached	reached.
Bring	brought	brought.		raught	raught.
Buy	bought	bought.	Seek	sought	sought.
Catch	caught	caught.	Teach	taught	taught.
Fight	fought	fought.	Think	thought	thought.
			Work	wrought	wrought.

The foregoing verbs, though now possessing a considerable amount of terminational uniformity, have come to have this similarity by somewhat different orthographic methods, notice of which might be interesting and instructive. About 1160, under French influence, the diphthong *au* began to make its appearance in English as the sign of a broadened sound of *a*. The Old English for *catch* was *gelæcean*, *gelucht*. The Picardese French *cacher* also had then the sense of *chasser*, to pursue. At that time the consonantal combination *ch* was not in use in English; but following the fashion of the Romance languages *ch* was adopted, and to indicate and regulate its pronunciation it was frequently spelled *tch*. Thus *cacher* became *catch*, and forming the past tense by internal vowel change, after the Old English model, *a* became *au*, and it appears as having its past participle in the "Peterborough Chronicle" as *cauhte*, and in the "Ormulum" as *bikahht*. In Old English *h* was a guttural. When the custom of dropping *h* began to be fashionable, an endeavour was made to insist on due aspiration by putting *e* or *g* before *h*; but, as Professor Earle says, the *gh* had little power to arrest the tendency of the language to divest itself of its gutturals, and *gh*, in its turn, has grown to be a dumb monument of bygone pronunciation, for though the spelling of the past tense of *catch* is *caught*, *gh* is silent, and the word is now pronounced *cawt*.

The Old English for *reach* and *teach* were *raecan* and *taecan*. The *c*, as already explained, took the pronunciation and sometimes even the form of *tch*. The *ea* sound was broadened into *au*, and, as in the case of *catch*, *cht* was changed into *ght*, making *raught* and *taught*. *Teach* is always used in the irregular or strong form, but *reach* is now always, except in poetry, employed with the weak and regular form—reach, reached, reached. Shakspeare makes Exeter say—

"He smiled me in the face, *raught* [=reached] me his hand."
—"*Henry V.*," IV. vi. 21.

And Queen Margaret, when Gloucester gives up his staff to Henry, speaks of—

"This staff of honour *raught*" [=reached].
—2 "*Henry VI.*," II. iii. 43.

The Old English for *buy* was *bycgen*. Sometimes this appeared in after-times as *bie*, but later as *buy*. The past and past participle were *bohte*. The *u*-sound was broadened into *ou*, and the guttural was intensified into *ght*, though it is now also silenced.

In Old English we find in the earlier time *bringe*, *brang*, *brungen*, but latterly it was conjugated *bring*, *broht*, *broht*—which, taking the guttural, became *brought*. In "Ormulum" we have *feohtan*. This was subsequently softened in the present into *fihte*, then *eo* being broadened into *ou*, and the guttural intensified, produced *fought*.

Seek took the two forms of *seke* and *seche;* the *e* was broadened into *o* in *sohte* and then *souhte*, whence we have *sought; biseche* underwent similar changes. Of *think* the old form was *thence*, with the pronunciation of *thenk;* of this the *n* seems to have been intrusive, for the past is *thohte* and the past participle *thoht*, whence by changing *o* into *ou*, and making the guttural intense, we have *thought*. *Work* in old English was *wyrce*, *ce* sounding *k*. Under the influence of *w* the *y* was changed to *u* and *o*, as *worche*, *worhte*, *worhte*. This also was broadened into *ou*, and the guttural form of *hte* was changed into *ght*, *wrought*.

The following we have been unable to arrange in any definite class:—

Clothe	clad	clad.	Hew	hewed	hewn.
	clothed	clothed.	Lie	lay	lain.
Come	came	come.	Melt	melted	molten.
Dig	dug	dug.	See	saw	seen.
Draw	drew	drawn.	Seethe	sod	sodden.
Eat	ate	eaten.	Slay	slew	slain.
Fly	flew	flown.	Stick	stuck	stuck.
Go	[went]	gone.	Swell	swelled	swollen.
Heave	hove	heaved.	Throw	threw	thrown.
	heaved	heaven.			

Though it is astonishing how sturdily men adhere to their old modes of speech, and how steadily the vernacular retains its power, yet it is pretty certain that by slow degrees these words are slipping out of use and tend to merge into the usual form of the weak verbs. This comes about in two ways: (1) fear of making mistakes in the use of them, and (2) the habit of seeking uniformity in ordinary modes of doing anything. It is only in reference to such words as are included

in the list of strong and mixed verbs that there is really any need for the caution which is often given as a *rule* in grammar. As it is a rule, however, that can have no bearing upon any regular verb—in which the past tense and past participle are both alike—and of which no breach is possible except in what are sometimes called irregular verbs, it falls rather into the minor rank of a caution than rises into the dignity of a rule. The caution is this, *The past tense ought not to be used instead of the past participle, nor the past participle instead of the past tense.* This, of course, implies that both are known and each distinguishable from the other. As there are only about 200 of them altogether, it does not seem to be a very difficult matter to acquire such a knowledge of them as would prevent the student from confounding or misapplying them. In the case of the poets some license in their use may be permitted, but there seems to be no reasonable ground for any mistake in the employment of them in prose composition. In some ranks of life we are not surprised to hear a person saying, "I *done* to him as I like done to myself," "I have *wrote* to him often," "I made up to him when I had *rode* half a mile." In certain other ranks, however, we occasionally hear errors not quite so palpable perhaps, but similar in kind and degree. In Pope's "Essay on Criticism," we have this couplet:—

"In the fat age of pleasure, wealth, and ease,
Sprung the rank weed, and *thrived* with large increase."

where *sprang* and *throve* ought to have been used. Gibbon uses the phrase, "The camp was almost immediately broke up." Sometimes one hears that "the case was lost even after the advocate had spoke two hours." In Rowe's translation of Lucan's "Pharsalia," we read

"Full in their eyes the dazzling flashes broke,
And with amaze their troubled senses stroke."

An expression of this sort, "I wish I *had went* to London," or "I think we *have sat* long enough," does not give us the same twinge of uneasiness as the words, "After I *was set* down, I waited till he came;" "I was then *bade* to go down stairs," but they are similar in the form of their disregard, not of grammatical accuracy alone, but of consistency of thought. We find now and then an incapacity to remember which of two similarly sounding or similarly spelled words we should employ. Take, for instance, the case of the strong verb *lie, lay, lain* or *lien*, in using which we can say "I lie, I lay, *or* I have lain on straw;" and the semi-weak verb *lay, laid, laid* (for *layed*), in the use of which we say "I lay, I laid, *or* I have laid down the book." In the book of Job these verbs are correctly used—*e.g.* "For now would I have lain still and been quiet" (iii. 13); "Oh that my griefs were weighed and my calamity laid in the balances together" (vi. 2). When the strong verbs have been properly committed to memory, we can always employ the past tense as it should be used, and by remembering that "the past participle ought always to be used after the auxiliary verbs *to have* and *to be*," there need be no confounding of past tenses with participles. It will be found a good exercise, having great influence in keeping the student right in the usage of these verbs, to arrange them in columns, and compose sentences including them immediately beside them. We subjoin a specimen:—

Get	I got my wish,	I have gotten the prize.
Take	I took the best,	I have taken what I got.
Mistake	I mistook the way,	I was mistaken for John.
Grow	The tree grew nicely,	The boy has grown tall.
Fly	The bird flew away,	The sparrows have flown off.
Flee	The robbers fled in fear,	We have fled to thee for help.
Crow	The cock crew thrice,	He would have crowed over us.
See	I tell what I saw,	Have you really seen that?
Saw	We sawed the whole block,	The whole block was sawn.
Throw	They threw the stone,	Who has thrown the stone?
Know	Did they say they knew?	Was this known of him?
Slay	Who slew the Rajah?	Was the Rajah slain?
Choose	I chose a new book,	Which book was chosen?
Blow	The wind blew terribly,	The ship was blown ashore.
Give	Who gave most readily?	How much was given?
Thrive	They throve by industry,	You have thriven well.
Cleave	Who clove this wood?	See the wood is cloven.
Cleave	He cleft the wood,	Bohun's helmet was cleft.
Cleave	We clave to the raft,	She has cleaved to us all along.
Smite	Who smote the Philistines?	The ship was smitten with plague.
Weave	He wove his fancies finely,	The garment was woven throughout.

A little reflection given to the sentences employed will readily show how these verbs ought to be used. One can easily see that though we may say "the people were *sent*," we cannot rightly say "the people were *went*." "The tree was hewed" is right; "the lesson was knewed" is wrong. In the same way, if the tables are regularly referred to, the source of any error will be quickly perceived.

We have now but a few words to say on Defective Verbs:—

Verbs which are not complete in their conjugation—that is, which do not bring into use all the regular variations of mood, tense, number, and person—are called *defective* verbs. The primary auxiliaries *am, have,* and *do*, as well as the secondary auxiliaries *may, can, must, shall,* and *ought*, are employed to supply the fundamental inflexional deficiency of English verbs as arranged in a logical conjugation or paradigm. But this only makes our verb composite, not defective. We recognize these compound forms as legitimate tenses, as the equivalents of the tenses in classically arranged verbs. We use them to give exactness, nicety, and point to verbal expressions. It is not of such (natural) deficiencies we intend to refer when we speak of defective verbs.

The primary auxiliaries are each able to be completely conjugated, but most of the secondary auxiliaries are unable to be employed, even when they fulfil the office of independent verbs, in all the conjugational forms; *may* and *might, can* and *could, shall* and *should, will* and *would* constitute only two forms in which as tenses they appear; *must* and *ought* have only one form. The verb *let* is in use only in the imperative, and in this way may be regarded as giving us the possibility of having, through it, a substitute for the first and third persons of the imperative of common verbs. The verb *use* as an auxiliary forms a sort of frequentative verb or verb of habit—*e.g.* Give mercy as thou usest to do; He used to write to me; John's disciples used to fast, &c.

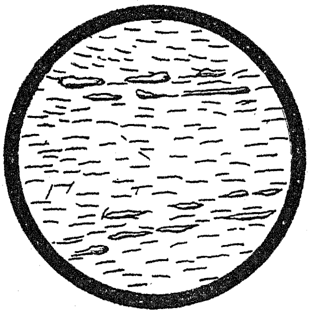
Avaunt, begone, beware may be instanced as imperative forms; *quoth* as an indicative equivalent to *says; wis* and *wist* are the present and past of an obsolescent verb of which mere remnants are now in use only in [imitation] antique phraseology—*e.g.* I wis, ere he wist, wot he not, had I wist, we do you to wit, &c. *Methinks* and *methought* are both in use as verbal forms for *I think* and *I thought;* so are *me seems, me seemeth* for "It seems to me." I *trow* as an equivalent for "I trust" or "place trust in one" is not generally used except in the first indicative, though Sir Walter Scott does use "he trowed" in "The Lady of the Lake" (vi. 10). *List* in "do as ye list, do as it listeth you, he did as he listed," &c., is defective. *Ycleped* in the sense of named is only a poetical form, and *worth*, a remnant of *worthen* (became, betake), is now only used in such phrases as "Woe worth the hour," though Robert of Gloucester said of the metropolis "London he is now *ycleped* and *worth* [shall be] evermore."

Ails, behoves, irks, needs, are used only in the third person singular—*e.g.* I know not what ails him; it behoves us to consider this; it irks me to do so.

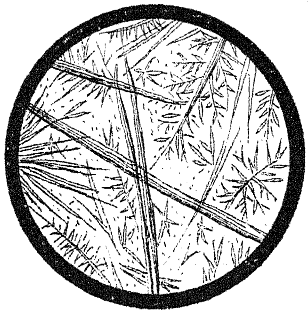
"What needs my Shakspeare for his honoured bones?"
—*Milton.*

It may be remarked that though strong verbs, following the tendency towards uniformity, may become weak, no weak verb becomes strong, nor is any fresh verb introduced into the language formed upon the strong model. The process of forming verbs according to the strong method of conjugation is obsolete, though our best writers carefully conserve, for the sake of variety and expressiveness, the strong verbs as much as possible. These strong verbs are the main pith of the language of the people, and few things show more clearly the substantial vitality of the native strain and spirit of the staple of our race than the manner in which the Celtic and Saxon elements of our language have held their place and power, notwithstanding the levelling tendencies of uniformity and the usurping grasp of the pedantic rules of mere grammarians.

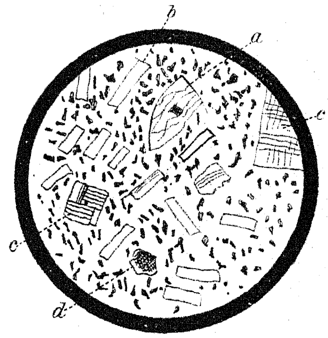
GEOLOGY.



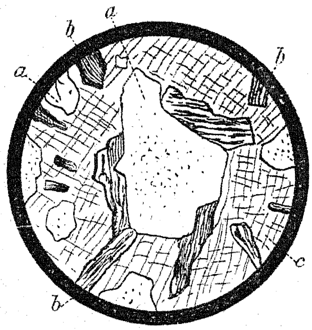
1. *Obsidian*, with *Microliths*, X 1/4 inch.



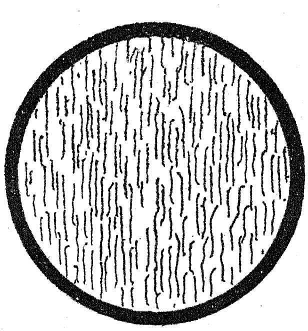
2. *Pitchstone*, *Arran*, (Forbes) X 15.



3. *Basalt*, *Arthur's Seat*, X 1 inch, a *Augite*, b *Plagio clare*, c *Labradorite*, d *Viridite*.

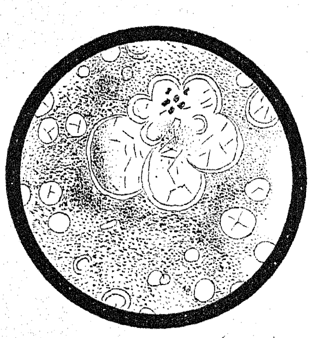


4. *Granite*, *Aberdeen*, X 1 inch. a *Quartz*. b *Mica*, c *Orthoclase*.

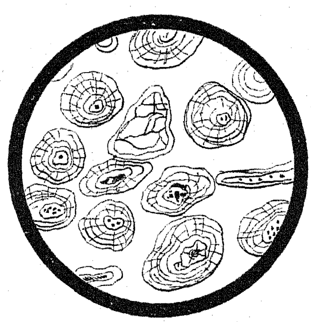


5. *Slate*, *Llanberis*, X 100.

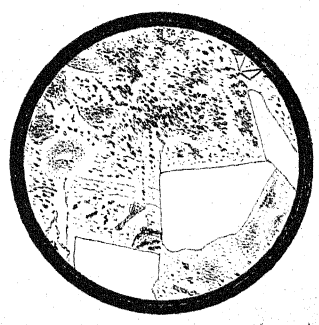
6. *Slate*, *Ffestiniog*, (Forbes) X 200.



7. *Chalk*, *Speeton* (Sorby) X 100.

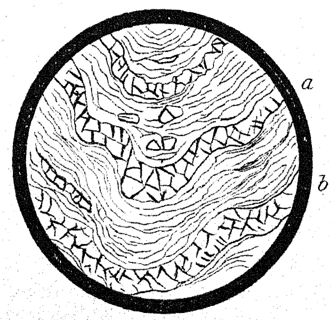


8. *Oolite*. *Forest Marble*. X 1 inch.

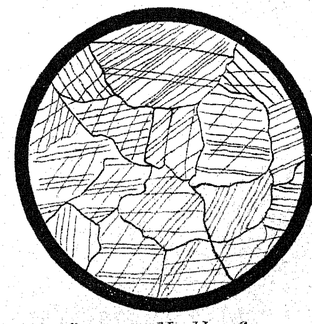


9. *Magnesian Limestone* (Sorby) X 50.

10. *Blazing Coal*, X 1 inch, with spores.



11. *Mica Schist*, *Holyhead*, X 1 inch. a *Mica*, b *Quartz*.



12. *Statuary Marble*. *Carrara*. X 1 inch.

GEOLOGY.—CHAPTER VII.

CLASSIFICATION OF PLUTONIC AND METAMORPHIC ROCKS—CHARACTERISTICS OF THE SUBCLASSES, AND THE RELATIONS BETWEEN THEM.

It constitutes the charm of science, that by its aid the commonest objects, those which meet and greet our eyes daily, are made instructive and capable of yielding pleasure. The wayside presents the observant eye with wonders, and the thoughtful mind endeavours to unravel their marvel and their mystery. A weed may call our thoughts to the classifications of botany, a straw floating on a streamlet's bosom may evoke the whole revelations, regarding force, made to us by natural philosophy, and a cinder (Plate IV., fig. 10) or a stone may lead us to considerations concerning "the chief things of the ancient mountains" and "the precious things of the lasting hills," of which geology informs us. Science is a knowledge of facts transformed by careful thought into a knowledge of the laws or the constant processes of nature, such as mere observation could never have reached. The popularizing of science therefore mainly means the extended culture of reflective observation. For the inducing of such finer seeing in a sense, practical skill is frequently indebted to science. But on the other hand the man of science has often been supplied with his knowledge of important facts by the practical worker among things. The shrewd practical miner preceded the theorizing geologist as a pioneer; the geologist now repays him by lighting him, in his subterranean workshop, to the stratum he seeks, or pointing out where he may find the mineral vein of which he has lost the traces.

It seems as if nature had expressly intended that geological phenomena should early receive attention. The coal-seam and the diluvial cave; the rifted rock and the close-packed silt; the seaboard with its high-built strata, and the river channel with its variedly eroded banks; terraces and beaches; bluffs and icebergs; upright cliffs and ice-worn slopes; mountain masses and finely-ground pebbles; boulders and sand-dunes; deltas and drifts; metals and marbles—all tempt man to inquiring observation; while, every here and there, islands like Arran and the Isle of Wight offer epitomes for study; and earthquakes and volcanoes, rain-fall and wind-sweep, heat and cold, exert themselves to tell men of the forces at work in producing these phenomena.

The rocks which engaged our attention in the last chapter form, if not a basis of crystallized matter beneath all stratified deposits, at least the lowest to a knowledge of which we have as yet attained; and they seem to conceal from observation whatever wonders may be going on beneath. The granites are regarded as the oldest of all known rocks. In this sense of being a formation beyond which we cannot penetrate, and upon which we find all stratified formations laid, the granites have been named *primitive*. As an indication of their igneous origin, they have been designated *Plutonic* (Gr. *Pluton*, the god of the lower world), and as opposed to *Neptunian* (Lat. *Neptunus*, the god of the sea), *i.e.* those of aqueous formation. As these fundamental rocks are found to contain no vestiges of animal or vegetable life, they have been classified as *azoic* or *hypozoic* (Gr. *a* privative, *i.e.* not having; *hypo*, beneath; and *zoe*, life); while, owing to their amorphous (Gr. *a*, without, and *morphē*, shape), irregular, and indeterminate form exhibiting no arrangement or succession of layers, laminæ, or strata, they are spoken of as unstratified. They come into view when, by the force of the heat which affects them, they have disrupted the stratified rocks and filled up the fissures and rents made in them by its disturbing action; or when, having pressed through the superimposed strata, they have overspread their surfaces with molten eruptions, and having cooled, overlye them in sheet-like expansions. Again, if these igneous discharges, after having burst through some sea-bottom and overlaid its floor with their fluent matter, have themselves been covered with aqueous *débris*, they may become interstratified with real sedimentary rocks. *Azoics* are known by their particles being free from water-wear, and from their being shining and sparkling, *i.e.* crystalline. If they have ever contained any records of life these have become obliterated. There are within them no discoverable mineralized remains of living organic substance.

As a general rule, stratified rocks repose on unstratified ones, though at their "surfaces of junction" they not unfrequently interfit or dovetail into one another—veins of the unstratified mass penetrating into the stratified portion. Sometimes they rise in wall-like masses, as vertical *dykes*, into fissures made in strata; at other times they cause *faults*, *hitches*, or *slips*, as different sorts of displacement are called with reference to the amount and kind of deviation made from their normal levelness of strata. In the large majority of instances such phenomena are to be seen in any mountain district, and they may be taken as indications that these igneous masses constitute the most primitive of the rocks to which observation has access. They are, so far as we can learn, the lithological origin of all stratified rocks. The unstratified portion of the earth's crust, so far as man has any knowledge of it, may be considered as rock formerly in a state of igneous fusion subsequently solidified by cooling, and when subjected to wear and waste, supply the original materials of the stratified rocks. Out of these unstratified materials—granite, syenite, porphyry, greenstone, trap, &c.—have been formed the successive layers of the earth's crust; and it is to the operation of thermic and volcanic agencies, and the energy in them, that the disturbance of the earth's surface and the changes to which it has been subjected are primarily due. Then aerial and atmospheric, chemical and aqueous change and waste gained sway, and the revolutions traceable in the condition of the earth were possible.

All real knowledge is related, branch to branch. Geology receives from Chemistry the knowledge of the ultimate elementary bodies (molecules or atoms) of which all things are composed (see page 91), the molecular structure of solids (page 93), the difference between metals and non-metallic bodies (pp. 91 and 173), the theory of combustion (pp. 459–462), and the doctrines of chemical combination (page 263) and of crystallization (page 264); from Natural Philosophy the theories of energy (page 316), the principles of motion and force (pp. 115–119), weight and pressure (pp. 356–360), light, heat, &c. Before proceeding further in the perusal of this chapter the student is recommended to make himself familiar with the information conveyed in the passages to which we have referred. This will save space and time, while it will not fail to convince him of the true unity of all right knowledge. He ought also to study most carefully the chapter on the chemistry of the earths (pp. 456–458), the whole of which is of great importance in geological pursuits. Of these earths all rocks are composed, and it is highly advantageous to know the chemical constitution and qualities of each as an aid to the comprehension of the phenomena of fusion, crystallization, stratification, &c., with which geology deals. Supposing that this information has been acquired as directed we proceed to supply further explanation of the topic on hand.

These rocks, igneous and crystalline, have been arranged by geologists into various groups more or less distinctly defined, of which *granite* and *gneiss* may be regarded as typical specimens. The general characteristics of these rocks have been explained at pages 539 and 451. But a closer inspection and a more accurate definition of some of their subclasses and varieties may be desirable. It is somewhat difficult to decide upon the best method of doing this, as geologists differ very much among themselves, not only in nomenclature, but also in their bases of classification. We prefer a method which, while offering evidence of difference to observation, also supplies a ground in reason for the definitions adopted. To aid the student as much as possible by illustration, to educate his appreciation of differences in appearance, and his perception of what is meant by the technical terms necessarily used in the teaching of science, we shall ask him to turn while reading the following paragraphs to Plate IV., and to note the references made to it so as to get as clear an idea as possible of what the descriptive language employed is intended to convey. By marking the similarities and the dissimilarities exhibited in the carefully prepared representations therein given, the words used may acquire a definiteness of meaning which they would not otherwise possess. There is a great difference perceptible to a competent observer between the largely crystalline Plutonic rocks which have been formed at

a great depth below the surface, under great pressure, and those glassy crystalline rocks which have been formed nearer the surface in more recent times, with finer grained materials, and under different rates of cooling pressure, &c.

Let the student notice the specimen of Aberdeen granite (fig. 4), with its confused, irregular, yet compact crystallization, remarkable for the absence in it of cellular cavities, and observe that silex, in its pure state as quartz, forms a very large proportion of its bulk, compared with its glassy, lustrous mica and its felspathic orthoclase (Gr. *orthos*, straight, and *clasis*, cleavage), whose lustre is pearly rather than vitreous, and he will be able to realize the descriptive language of page 539, as well as to recognize more accurately the thing itself. If he next turns to the Arran pitchstone (fig. 2) which pierces through, in a dyke 30 feet wide, and sometimes even overlies in columnar masses the general sandstone strata of the eastern shore of that island, he will see that it is a silicious, mineral-like, igneous rock, the texture of which is more glassy and less granular than granite. Its colours are extremely various, and it is found not only in amorphous but in concrete masses, sometimes porphyritic and at others resembling pearlstone. Among modern volcanic rocks the analogue of these two specimens is seen in fig. 1. It is commonly known as volcanic glass, but has received the scientific designation of *Obsidian*, from Obsidius, the name of the Roman who first, according to Pliny, recognized this glassy lava as a distinct mineral, and brought a black variety of it from Ethiopia to Rome to be made into mirrors. It is hard, brittle, vitreous in lustre, exhibits, when fractured, conchoidal (Gr. *conchē*, a shell, and *eidos*, form) curves, is sometimes translucent and even semi-transparent, varies in colour, and is widely distributed. Its crystallization is not coarse in structure, like the stony lava of Arthur's Seat (fig. 3), but finely needle-shaped. In chemical composition it agrees not only with the light, spongy, friable lava product, the pumice stone of commerce, but with many of the highly silicated crystalline and semi-crystalline rocks, and is of special interest to the geological student for the evidence it yields of crystallization produced by percolating moisture. The three foregoing illustrations may be taken as specimens of what has been called the *acid* group of rocks—*i.e.* those which are characterized by (1) the high percentage of silex, silicic acid, or "earth of flints," which is included as the predominating ingredient in its material (reaching from 70 to 80 per cent.); and (2) by a strikingly low average of basic matter, such as iron, lime, magnesia, soda, &c. As a rule, too, they do not decompose easily. Yet from the granite rocks of Cornwall and Devon, against whose adamantine masses the seas have dashed their billows for thousands of years without having scooped out any very remarkable hollow, we obtain that milky white, unctuous plastic earth, which as kaolin or China clay, is employed in the potteries of Worcester and Stafford in the manufacture of pure porcelain. These rocks, decomposed and disintegrated *in situ* by the action of atmospheric water, have their soda and potash dissolved out of them, and are reduced to an insoluble silicate of alumina, soft and friable, which is known, under the old Cornish name of *grouan*, as the material used for Wedgwood ware.

Another group of these rocks may be regarded as *basic*—base being, in chemistry, the word used to denote such alkaline substances as combine with an acid into a salt or a metal. These rocks are generally rich in lime, magnesia, soda, iron, &c., and seldom show a larger amount than from 45 to 55 per cent. of silica. Of these one of the most remarkable is basalt—a specimen of which (fig. 3) we take from Arthur's Seat, Edinburgh—the materials of which, though obtained originally from some subterranean source, probably by volcanic agency, have received their later arrangement under the influence of water, and form on this account a sort of geological puzzle. The central and upper part of the hill, as well as the columnar masses of "Samson's ribs," are decidedly basaltic in structure. The mass of trap of which the hill consists is an upheaval through the carboniferous strata, with a soft incompact claystone on the top, obtaining a total elevation above the sea-level of 822 feet. Basalt is a hard, compact, dark-coloured rock, often found in regular columns like the colonnaded mural precipices of the Giant's Causeway, the symmetrically arranged pillars of Fingal's Cave (Staffa), or the Illawarra coast of New South Wales. It is composed of hornblende and felspar, with some little iron. It appears in two varieties—trap-basalt and lava-basalt—the latter being the more recent in formation, and developing rather augite than hornblende. The specimen selected (fig. 3) contains some of the brilliant, though dark-green, augite or pyroxene, plagioclase (Gr. *plagios*, slanting, *clasis*, cleavage), an opalescent felspar, brilliant and changeable in hue, called, from the coast of the peninsula where it is principally found, Labradorite, and is mottled with a green-colouring matter designated viridite. The mica schist, a slaty rock from Holyhead (fig. 11), has the original texture of the rock entirely obliterated by metamorphic agency. It mainly consists of quartz and mica, to the latter of which it owes its glistening scaly appearance and its name. As it readily splits off into thin scales of differing mineral matter, it is characterized as foliar, laminar, or schistose.

It will fall to us, in a subsequent chapter, when dealing with sedimentary rocks, to characterize and compare the other illustrations on Plate IV. with those to which we have already referred, but meanwhile it may be well to conclude what we have to say on the granite groups or subclasses:—

1. *Granite proper* has a distinctly mottled appearance, and hence its different crystals of quartz, felspar, and mica can be readily recognized. The quartz—known in its purer forms as rock-crystal—which gives it hardness, appears in white, glassy-looking, and translucent forms. The felspar (Ger. *feldspath*), a compound of silica, alumina, and potash, is the soft gray, easily scratched ingredient. According to the amount of oxide of iron or manganese which it contains, the granite darkens from white to cream-colour and all the intermediate shades to red. Mica (Lat. *mico*, I glisten)—commercially known as Muscovy glass—consists of shining glassy particles of silicate and oxide of iron. It is smooth, soft, laminar, and varies in degree of colour and transparency. These are not chemically combined, but cohesively agglomerated by pressure. Felspar in a crystallized state is the essential. Mica is sometimes absent, as in the binary granite of Muncaster Fell, Cumberland.

2. *Syenite* (from Syene in Upper Egypt, where it was first found) has hornblende instead of mica, the felspar often predominates, and is lamellar, as in the singular granite of Strontian, near Loch Sunart, in Argyleshire.

3. *Protogyne* (Gr., first-born) (1) has, when *green*, talc or chlorite instead of mica. The felspar is gray or red, but the prevailing colour is dark-green; and (2) when *red*, talc and steatite of a reddish-brown hue, but is prevailingly red. Indeed it may be further varied according as potash or soda abounds in the felspar, and the mica, if any, has a base of magnesia or lime. These rocks form the higher peaks of the Alps and many of the marked mountains of Cornwall.

4. *Porphyritic granite* (Gr. *porphyra*, purple) is hard and small-grained. It is conspicuously studded with felspathic crystals, as in the fine-grained granite of Westdale in Westmorland.

5. *Serpentine* is mottled so as to resemble a serpent's skin, and consists of closely compacted quartz, chlorite, steatite, &c.

6. *Pegmatite* or graphic granite has mica with a potassic base in it, and the crystals of quartz and felspar are often so arranged that a polished section of it has the appearance of being inscribed with Hebrew writing. It is very rich in silica, and the finest kaolin is produced by its decomposition, through the agency of atmospheric water.

Such are the main varieties of granite, but through the introduction of modifying and accidental additions or substitutions, such as chloride, schorl, actinolite, &c., several other granitic and granitoid varieties occur, as in the hypersthene of the Valteline valley of the Adda in North Italy. It will be observed that this definition and description of granite refers to its material constituents and not to its determinate age in the world's history. In point of fact there may be traced—from the modern, superficially deposited, vesicular pumice-stone of the most recent volcano, through the obsidian vitreous lava—an uninterrupted series of aggregations, showing changes gradually acquiring conformity to granite. No doubt, as the granitic rocks are far more numerous than the trappean

rocks, many of them must be of prior date, but this requires in every case to be inductively determined from the nature and circumstances of the special aggregation under review and the strata which adjoin it. Observation must really supply the grounds for accepting any fixed or supposed period as that at which any particular mass of granite has been erupted through the consolidated crust of the earth. In whatever era any convulsive upheaval of molten matter may have overspread a given area, or the fusion of any such matter closed by its concretion into rock, granite retains its characteristics and is known by them, though it is not accurate to reason conversely that because granite is the oldest known form of rock the period of its manifestation at any place must be the remotest possible to the imagination of man.

The general relation among the granitic igneous rocks of the past and the lavas of those which are more modern, as exemplified in the specimens exhibited on the Plate, show that though they may differ in structure they have been really similar in origin. They always rise up from below, and generally show a connection between their upheaved and ejected masses and the source whence they drew their supply. The varieties of rock comprised under the gneiss type, on the other hand, are very numerous. The term gneiss, like granite, is used in a very wide sense, according to the actual mineral structure of the several kinds of rocks; and their deviations from the normal type correspond, in great measure, with those occurring in the granitic series. Gneiss, however its particles may be disposed, is hard, tough, and crystalline, having its crystals indistinct and confused in their aggregation; it exhibits, when carefully examined in its curves and flexures, the lines of stratification and the signs of deposition in layers. Owing to their hardness and the indistinctness of their laminar structure, it is often difficult from a mere hand-specimen to determine whether a piece of rock is really granite or gneiss, and hence those compound masses which are obscurely marked are frequently spoken of as granitoid—*i.e.* granite-like. The main subclasses of gneiss are—

(1) Gneiss proper, composed of the same three minerals as granite—viz. quartz, felspar, and mica—exhibiting similar variations in the proportions of its materials, the magnitude of its crystals, and the [possible] presence or absence of different [accidental] ingredients, and more or less distinctly laminar, foliated, or even schistose.

(2) Syenitic gneiss, having as its constituents quartz, felspar, and hornblende, the felspar being generally red and the hornblende dark green.

(3) Porphyritic gneiss, having large irregular and conspicuous granulations of quartz or oligoclase felspar mottling and rubifying its surface.

(4) Quartz and quartzite, having its aggregated quartz, oxide of silicon, granular and flaked with mica. In quartzite the grains seem to blend into a homogeneous silicious paste or magma (Gr., kneaded mass, as dough, &c.)

The gneisses, then, may be regarded as the types of metamorphic rocks—*i.e.* of derivative rocks having a bedded structure in which a change has been wrought on their normal sedimentary form, promoting in them a crystalline structure and imparting to them the appearance of plutonic rocks. The exact nature of the causation by which the alteration has been effected is not as yet with certainty known. Gneiss occurs in formations of almost every age. When confined to a narrow belt along the boundary of some intrusive and erupted mass the metamorphism or paroptesis (Gr., baking and hardening) to which it has been subjected is termed local, and the zone affected by it varies in its extent with the size of the incandescent intrusion. In such cases the metamorphism has evidently been caused by the intense heat of the molten overflow. In other cases the metamorphic effects are regional. Over large districts and on strata of great extent and thickness in almost all areas of volcanic disturbance and upheaved mountain land, the stratified rocks seem as if they had undergone an incipient fusion called *metapepsis* (from the Greek word meaning change by softening), by heat, in water, under great pressure, and so have passed into a crystallization which has not quite destroyed their characteristics of foliation and parallel cleavage. Chemical action may also, by *mythylosis*, be metamorphic, as in the case of the rock of Lizard Point, Cornwall, originally an igneous diallage of foliated structure, partly metamorphosed into serpentine. The serpentines of the Laurentian formations in Canada, Scotland, Ireland, &c., have probably a similar origin.

The ruling difference of ideal between granitic and gneissian masses appears now to be one not of age but of constitution. The former are regarded as having been crystallized when in a state of perfect fusion, the latter when in a state of imperfect fusion, pressure being in both cases, though in various proportions, also active as an agent, and probably affecting the chemical attraction of the substances of these rocks. From these, the deepest-seated strata in the rock-crust of the earth, geologists proceed to build up an idea of the accumulations and superpositions which have marked the past phases of the life-history of the globe amid all the modifications of the superficial configurations of the earth, and from these they seek to extract the secret of the strange variety and incidents which constitute the story of man's dwelling-place.

ALGEBRA.—CHAPTER VI.

THE DIVISION OF FRACTIONS—RECIPROCALS.

It has been shown that the multiplication of a number—integral or fractional—by a fraction is, in reality, a compound operation, (1) of multiplication and (2) of division. If, for instance, we multiply the integer 8 by the fraction $\frac{3}{4}$, we first multiply the whole number 8 by the whole number 3, the numerator, and have as a result the integer 24. The true multiplier, however, is not 3 the integer, but the fourth part of the number. Therefore the result is four times too much, and requires to be divided by 4—the result of which is the proper answer, 6. Again, if we require to multiply $\frac{1}{2}$ by $\frac{3}{4}$ we bring these fractions first to a common denominator, as $\frac{2}{4} \times \frac{3}{4}$. Our first multiplication of $\frac{2}{4}$ by 3 yields $\frac{6}{4}$; but that, as before, is four times too great. The first product requires now to be divided by 4, which is done by multiplying the denominator by 4, and so getting as our result $\frac{6}{16} = \frac{3}{8}$.

Division is the reverse of the operation of multiplication. A whole number is divided by a fraction, or a fraction by a whole number, either by (1) dividing the numerator, or (2) by multiplying the denominator, for then the multiplier becomes a divisor and the divisor a multiplier, and so the operation is a multiplication reversed. A fraction is divided by a fraction precisely in the same way as a whole number is; for when the fractions are brought to a common denominator the numerators really become to each other as whole numbers. It is obvious that $\frac{6}{16}$ divided by $\frac{2}{16}$ is really $6 \div 2 = 3$. So $\frac{2}{7} \div \frac{3}{5}$, when the fractions are reduced to a common denominator, become really $\frac{10}{35} \div \frac{21}{35}$, and are equal to $\frac{10}{21}$, which is the answer; an answer, however, which is attained more simply by the rule usually employed in working such questions, viz.:—Invert the divisor, and proceed as in multiplication, as $\frac{2}{7} \div \frac{3}{5} = \frac{2}{7} \times \frac{5}{3} = \frac{10}{21}$, *Ans.*

Precisely similar, in the mode of their working, to the foregoing numerical operations, are algebraic ones, viz.:—

$$(1)\ 1 \div \frac{1}{x} = \frac{1}{1} \div \frac{1}{x} = \frac{1}{1} \times \frac{x}{1} = \frac{x}{1} = x,\ \textit{Ans.}$$

$$(2)\ \frac{1}{x} \div \frac{1}{x^2} = \frac{1}{x} \times \frac{x^2}{1} = \frac{x^2}{x} = x,\ \textit{Ans.} \qquad (3)\ \frac{2-x}{y} \div \frac{2-x}{x}.$$

This by inversion becomes $\frac{2-x}{y} \times \frac{x}{2-x}$, in which the numerator of the former cancels the denominator of the latter, and the result is $\frac{x}{y}$, *Ans.* Let us next work out the following:—

(4) $\frac{a}{b}\div c$? The dividend and divisor, when multiplied by b, give $a\div bc$; that is $\frac{a}{bc}$, which is just the same as $\frac{a\div c}{b}$, *Ans.* From this result we see that without difference of signification $\frac{a}{b}\div c$ may be written (1st) $\frac{\frac{a}{b}}{c}$, (2nd) $\frac{a}{b\times c}$, (3rd) $\frac{a\div c}{b}$.

Hence algebraists deduce the following rule to divide a fraction by any quantity:—*Multiply its denominator by that quantity and retain the numerator, or divide its numerator by that quantity and retain its denominator.* These rules are exactly the inverse of those given at page 542 for multiplication, and are exemplified by the following as by the previous cases:—

$$(1)\ \frac{a}{x}\div(x+1)=\frac{x}{xx+x}.\quad (2)\ \frac{a+2}{x-a}\div(x+a)=\frac{a+2}{xx-aa}.$$

$$(3)\ \frac{aa-xx}{x-v}\div(a+x)=\frac{(aa-xx)\div(a+x)}{x-v}=\frac{a-x}{x-v}.$$

Common factors may be expunged from the numerator and denominator as in the preceding rules (see pp. 445, 543). Thus $\frac{9ab}{10cd}\div 3abc=\frac{9ab}{10cd\times 3abc}=\frac{9ab\div 3ab}{10cd\times c}=\frac{3}{10ccd}$.

Again, let the question be $\frac{a}{b}\div\frac{c}{d}$? We here multiply the dividend and divisor by bd, and obtain $bd\times\frac{a}{b}\div bd\times\frac{c}{d}$, and by reduction $ad\div bc$, which means $\frac{ad}{bc}$. But $\frac{ad}{bc}$ is the product $\frac{a}{b}\times\frac{d}{c}$, and from this fact we learn that

$$\frac{a}{b}\div\frac{c}{d}\text{ means }\frac{a}{b}\times\frac{d}{c},\text{ which is }\frac{ad}{bc};$$

and we can generalize the experience gained thus:—*To divide by a fraction is the same as to multiply by that fraction inverted.*

The following exercises are arranged in such a way that those who have attended to the preceding instructions should be able to perform them easily in the order given. In most of them a test-step has been left unshown. This the student is expected to fill up properly, and by so doing to see that the answer given follows from the observance of the foregoing rules.

We may, perhaps, notice more fully here that compound fractions, *i.e.* those which express the fraction of a fraction, are reducible into simple fractions by multiplying the numerators together for a new numerator and the denominators for a new denominator, as $\frac{3}{4}$ of $\frac{5}{7}=\frac{15}{28}$, and $\frac{a}{b}$ of $\frac{c}{d}=\frac{ac}{bd}$. Again, $\frac{a}{b}$ of $\frac{c}{d}$ of $\frac{e}{f}=\frac{ace}{bdf}$. In the case of complex fractions, *i.e.* those in which either the numerator or denominator or both are fractions, they are simplified in expression by taking the product of the upper and lower quantities (or extremes) for their simplified numerator, and the product of the middle ones (or means) for their simplified denominator. Of course, any common factor may be cancelled in either of the extremes if it is also cancelled in either of the means; as

$$(1)\ \frac{1-\frac{x}{2}}{4x}=\frac{\frac{2-x}{2}}{4x}=\frac{2-x}{2}\times\frac{1}{4x}=\frac{2-x}{8x}.$$

$$(2)\ \frac{2x}{x-\frac{1}{3}}=\frac{\frac{2x}{1}}{\frac{3x-1}{3}}=\frac{2x}{1}\times\frac{3}{3x-1}=\frac{6x}{3x-1}.$$

$$(3)\ \frac{x+2}{1-x+\frac{1}{2-x+\frac{3}{x}}}=\frac{x+2}{1-x+\frac{x}{2x-x^2+3}}=[?]=\frac{6+7x-x^3}{3-3x^2+x^3}.$$

EXERCISES.

$$(1)\ \frac{4x^2}{5}\div\frac{x}{3}=\frac{4x^2}{5}\times\frac{3}{x}=[?]=\frac{12x}{5},\ \textit{Ans.}$$

$$(2)\ \frac{3ab}{4pq}\div\frac{5mn}{6xy}=\frac{9abxy}{10mnpq},\ \textit{Ans.}$$

$$(3)\ \frac{1}{x^2-y^2}\div\frac{1}{x-y}=\frac{1}{x^2-y^2}\times\frac{x-y}{1}=\frac{1}{x+y},\ \textit{Ans.}$$

$$(4)\ \frac{xy}{7}\div 4x=[?]=\frac{xy}{28x}=\frac{y}{28},\ \textit{Ans.}$$

$$(5)\ \frac{12x}{5}\div 4x=\frac{12x}{20x}=\frac{3}{5},\ \textit{Ans.}$$

$$(6)\ \frac{x^2-y^2}{(x-y)^2}\div\frac{x^2+xy}{x-y}=[?]=\frac{1}{x},\ \textit{Ans.}$$

$$(7)\ \frac{x-y}{x^2-xy}\div\frac{x^2-xy}{x^2-xy^2}=[?]=\frac{x-y}{x^2(x+y)},\ \textit{Ans.}$$

$$(8)\ \frac{(x+y)^2}{x-y}\div\frac{x+y}{(x-y)^2}=[?]=x^2-y^2,\ \textit{Ans.}$$

$$(9)\ \frac{3}{4}y-\frac{5}{8}z\div\frac{15y}{16z}=[?]=\frac{12yz-10x^2}{15y}=\frac{4z}{5}-\frac{2x^2}{3y},\ \textit{Ans.}$$

$$(10)\ \frac{a+x}{b^2+2bx+x^2}\div\frac{1}{b+x}=\frac{a+x}{(b+x)^2}\times\frac{b+x}{1}=\frac{a+x}{b+x},\ \textit{Ans.}$$

Every fraction is to unity, *i.e.* 1, as its numerator is to its denominator, for the denominator is the number of equal parts into which unity is divided, and the numerator indicates the number of these contained in the fraction. The quotient of 1 divided by any quantity is called by mathematicians the *reciprocal* of that quantity, because these hold, as the word reciprocal signifies, a constant and mutually interchangeable relation to one another. Thus, somewhat restricting the word in its scientific usage, mathematicians define a reciprocal quantity as any one which exhibits precisely the same relation with reference to any other quantity as that quantity does to it: $\frac{1}{a}$ is the reciprocal of a, and $1\div\frac{a}{b}=1\times\frac{b}{a}=\frac{b}{a}$ is the reciprocal of $\frac{a}{b}$. But $\frac{1}{a}$ and $\frac{b}{a}$ result, as we see at a glance, from $\frac{a}{1}$ and $\frac{a}{b}$ by the inversion of their terms.

Integral quantities, we know, may be regarded as fractions having 1 for their denominator. The reciprocal of any quantity is a fraction formed by inverting the terms of the proposed fraction. From this and the preceding rule it follows that *to divide by any quantity is the same as to multiply that quantity by its reciprocal*, and *vice versâ.* Thus $a\div b$ is $a\times\frac{1}{b}$ and $a\div\frac{1}{b}$ is $a\times b$. The formulæ may be shown thus—

$$(1)\ \frac{p}{q}\times a\text{ or }a\times\frac{p}{q}\text{ is }a\div\frac{q}{p}.$$

$$(2)\ a\div\frac{p}{q}\text{ is }a\times\frac{q}{p}\text{ or }\frac{q}{p}\times a.$$

In which, as we were led to expect, the processes and the results are the reverse of each other.

From the foregoing formulæ it also follows that the product of any quantity multiplied by its reciprocal must be 1, as

$$\frac{3}{4}\times\frac{4}{3}=\frac{12}{12}=1\text{ and }\frac{a}{b}\times\frac{b}{a}=\frac{ab}{ab}=1.$$

The following are examples fully illustrative of the application and use of this rule:—

$$(1)\ \left(\frac{a}{b}+\frac{b}{a}\right)\div\frac{a}{b}=\left(\frac{a}{b}+\frac{b}{a}\right)\times\frac{b}{a}=1+\frac{bb}{aa}$$

(2) $\dfrac{\frac{a}{b}}{\frac{x}{y}}$ means $\dfrac{a}{b} \div \dfrac{x}{y} = \dfrac{ay}{bx}$. (3) $\dfrac{\left(\frac{axx}{by}\right)}{\left(\frac{cxx}{dyy}\right)}$ is $\dfrac{axx}{by} \div \dfrac{cxx}{dyy} = \dfrac{ady}{bc}$.

$$(4)\quad \frac{\left(\frac{a+b}{2}\right)}{\left(\frac{a-b}{2}\right)} = \frac{2(a+b)}{2(a-b)} = \frac{a+b}{a-b}.$$

$$(5)\quad \frac{\left(\frac{a}{q}\right)}{\left(\frac{p}{q}\right)} \div \frac{\left(\frac{x}{y}\right)}{\left(\frac{m}{n}\right)} = \frac{\frac{a}{q}}{\frac{p}{q}} \times \frac{\frac{m}{n}}{\frac{x}{y}} = \frac{amn}{pxy}.$$

$$\left(\frac{m}{n}-\frac{x}{y}\right) \div \left(\frac{p}{q}-\frac{a}{b}\right) = \frac{my-nx}{ny} \times \frac{bq}{bp-aq} = \frac{bmqy-bnqx}{bnpy-anqy}.$$

It must not be supposed, as it might be, that in cases of this sort it would be enough to multiply the *dividend* by the reciprocals of the individual fractions of the divisors: we must multiply by the reciprocal of the *whole divisor*, and the reciprocal of $\frac{p}{q}-\frac{a}{b}$ is not $\frac{q}{p}-\frac{b}{a}$ but $\frac{bq}{bp-aq}$, as may be readily shown; thus the reciprocal, according to the definition just given, is $1 \div \left(\frac{p}{q}-\frac{a}{b}\right)$. Multiply both divisor and dividend by bq, the least common multiple of b and q, and this becomes $bq \div (bp - aq)$, which is $\frac{bq}{bp-aq}$, as stated above. When, however, the divisor consists of several fractions, the reduction is more readily effected by the following method, which is deduced immediately from the algebraic proposition $\frac{a}{b}=\frac{ma}{mb}$ and the notation of division, as already explained.

$$\left(\frac{m}{n}-\frac{x}{y}\right) \div \left(\frac{p}{q}-\frac{a}{b}\right) = bnqy\left(\frac{m}{n}-\frac{x}{y}\right) \div bnqy\left(\frac{p}{q}-\frac{a}{b}\right)$$

$$\text{or} \quad . \quad . \quad . \quad . \quad = \frac{\frac{m}{n}-\frac{x}{y}}{\frac{p}{q}-\frac{a}{b}} = \frac{\left(\frac{m}{n}-\frac{x}{y}\right)bnqy}{\left(\frac{p}{q}-\frac{a}{b}\right)bnqy} = \frac{bmqy-bnqx}{bnpy-anqy}$$

The multiplier $bnqy$, it will be observed, is the least common multiple of the denominators of the fractions composing the dividend and divisor. The following are examples of the same kind:—

$$(1)\ \frac{\frac{a}{b}-\frac{c}{d}}{\frac{a}{d}+\frac{b}{c}} = \frac{\left(\frac{a}{b}-\frac{c}{d}\right)bcd}{\left(\frac{a}{d}=\frac{b}{c}\right)bcd} = \frac{acd-bcc}{abc+bbd}. \quad (2)\ \frac{\frac{x}{y}+1}{1-\frac{y}{x}} = \frac{xx+xy}{xy-y}.$$

$$(3)\ \frac{\frac{1}{1+x}-x}{1-\frac{x}{1+x}} = \frac{\left(\frac{1}{1+x}-x\right)\left(1+x\right)}{\left(1-\frac{x}{1+x}\right)\left(1+x\right)} = \frac{\frac{1+x}{1+x}-(1+x)x}{1+x-\frac{(1+x)x}{1+x}}$$

$$=1-x(1+x). \quad (4)\ \frac{\frac{1}{1+x}}{1-\frac{1}{1+x}} = \frac{1}{x}. \quad (5)\ \frac{\frac{1}{1+x}+\frac{x}{1+x}}{\frac{1}{1-x}-\frac{x}{1+x}}=1$$

All the foregoing formulæ are correct, and will produce the same results, whether the letters used represent fractions or are removed and have numerical fractions substituted for them. We proceed to prove the first formula—$(m+n)a=am+an$, when m, n, a are respectively the fractions $\frac{p}{q}$, $\frac{r}{s}$, $\frac{x}{y}$.

$$\text{Here } m+n=\frac{p}{q}+\frac{r}{s}=\frac{ps+qr}{qs}$$

$$\therefore (m+n)\,a=\left(\frac{ps+qr}{qs}\right)\frac{x}{y}=\frac{(ps+qr)x}{qsy}=\frac{psx+qrx}{qsy}$$

Exercise.—Show now, by means of the preceding, that the formula $(a+b)\ (a-b) = aa - bb$ is true when a and b represent respectively the fractions $\frac{m}{n}$ and $\frac{p}{q}$.

To prove the second formula, viz. $\frac{a}{b}=\frac{ma}{mb}$ when a, b, and m have the same values as in the preceding example, we proceed thus:—

$$\frac{a}{b}=\frac{\frac{p}{q}}{\frac{r}{s}}=\frac{p}{q}\div\frac{r}{s}=\frac{ps}{qr}$$

$$ma=\frac{x}{y}\times\frac{p}{q}=\frac{xp}{qy} \qquad mb=\frac{x}{y}\times\frac{r}{s}=\frac{xr}{ys}$$

$$\therefore \frac{ma}{mb}=\frac{\frac{xp}{yq}}{\frac{xr}{ys}}=\frac{xp}{yq}\div\frac{xr}{ys}=\frac{xyps}{xyqr}$$

$$\text{But } \frac{xyps}{xyqr}=\frac{xy}{xy}\times\frac{ps}{qr}=\frac{ps}{qr}=\frac{p}{q}\div\frac{r}{s}=\frac{\frac{p}{q}}{\frac{r}{s}}=\frac{a}{b}.$$

$$\text{Hence } \frac{ma}{mb}, \text{ which is } \frac{\frac{xp}{yq}}{\frac{x}{y}\times\frac{r}{s}}, \text{ is } \frac{\frac{p}{q}}{\frac{r}{s}}, \text{ which is } \frac{a}{b}.$$

Exercise.—Show, by following the operations in the preceding example, that the following formulæ are right when $a=\frac{m}{n}$, $b=\frac{p}{q}$, $c=\frac{r}{s}$, and $d=\frac{x}{y}$:

$$(1)\ \frac{a}{b}+\frac{c}{d}=\frac{ad+ac}{bd} \qquad (2)\ \frac{a}{b}\times\frac{c}{d}=\frac{ac}{bd}$$

$$(3)\ \frac{a}{b}-\frac{c}{d}=\frac{ad-bc}{bd} \qquad (4)\ \frac{a}{b}\div\frac{c}{d}=\frac{ad}{bc}$$

ASTRONOMY.—CHAPTER VIII.

ATTRACTION OF GRAVITATION—ITS ACTION ON ORBITS OF PLANETS—DETERMINATION OF MASS OF PLANETS—PHENOMENA OF TIDES—TIMES OF HIGH WATER—SPRING TIDES—NEAP TIDES—HEIGHT OF TIDES—VELOCITY OF TIDAL WAVES—TIDES IN RIVERS—THEORY OF THE TIDES.

ALL matter on the earth, whether in a solid, liquid, or gaseous state, is subjected to the law of gravity, or possesses weight. [See NATURAL PHILOSOPHY.] Gravity is a force inherent to the matter of which the earth is composed, and the energy with which it is exercised depends on the distance of the body which is influenced, the energy increasing when the distance is diminished, and decreasing when the distance is increased. Thus the flattening of the two poles of the earth and the swelling out of the globe towards the equator cause the distance from the surface to the centre of the globe to increase continually as the equator is approached. The force of gravity is therefore more intense at the poles than at the equator. The law which regulates this diminution of the force of gravity will be found fully explained in Natural Philosophy; but it is necessary here to briefly recapitulate certain points in order to clearly comprehend the laws of universal gravitation in connection with planetary orbits. To understand the laws well let a heavy body be placed on the earth's surface, and therefore distant from the centre by the earth's radius, in round numbers 4000 miles. Let this body be then removed twice the distance, 8000 miles away, the action of gravity will then be four times less; if the body is placed three times the distance off, that is, 12,000 miles, the action of gravity will be nine times less, and so on, the force of gravity or attraction of gravitation diminishing in the inverse ratio of the squares of the distance. Again,

the force of gravity is measured by the space a body falls through during the first second, so that if a body requires a second to fall from a height of 16 feet to the surface of the earth, if it is removed to a distance double that of the earth's radius it will not fall more than 4 feet during the first second of its fall; at a distance sixty times as great as the earth's radius it will not fall more than the one-twentieth part of an inch. Now this number gives exactly the diminution of the energy of terrestrial gravity on a heavy body situated in space at the mean distance of the moon.

As the earth exercises the force of gravitation on bodies situated at any distance in space, it must of necessity act on the moon, and its action should be equal to that named. Newton showed that this was so, and that the moon in moving in its curvilinear orbit falls nearer towards our earth that very quantity in a second. It is this continual falling, combined with the centrifugal movement [see NATURAL PHILOSOPHY] (which if left to itself would impel the moon into space), that produces the elliptical movement of the moon's orbit. In extending the law of gravitation to the bodies of the solar system Newton demonstrated that if the planets move round the sun, describing elliptical curves according to Kepler's laws, it is because that they are subjected to a constant force, located, as it were, in the sun, a force the direction of which is in a right line joining the planet and the common focus, and that this force of gravity exercised by the sun on the planets was in the inverse ratio of the square of their distances. It is thus the force of gravity, exercised by the larger mass of the earth, which maintains the moon in its orbit; it is the same force exercised by the preponderant mass of the sun which also maintains the planets, the comets, and other cosmical bodies in their elliptical orbits round the sun, and prevents them from flying off into space, following the impulse with which they are incited, and thus breaking up our system.

The nature of the substances of which the several planets are composed is quite independent of the action of gravity, and the mass of the sun would act with an equal energy on a unit of the mass of all the planets if they were all placed at the same distance from the common centre.

It is a first principle of mechanics that every action of one material body on another necessarily supposes a reaction equal, and in a contrary direction; consequently, if the earth and the other bodies of the solar system gravitate towards the sun, the sun must also gravitate towards each of them. The same law rules in each secondary system composed of a central planet and its satellites, as all the molecules of matter gravitate towards each other in the ratio of their masses, and reciprocally as the squares of their mutual distances.

In the determination of the mass of a planet a unit of mass or of weight is taken in connection with that to be measured; such a unit taken for comparison may be either the mass of the sun or the mass of the earth. Newton's law shows that the attraction of a sphere acts on all external bodies as if the entire mass of the sphere were concentrated at its centre, and therefore any heavy body falling on the surface of the earth must be considered as situated from the centre of attraction at a distance equal to the radius of the earth. The mass of the earth, therefore, acting on a body 4000 miles distant causes it to fall 16 feet in one second. But the earth itself gravitates towards the sun, and the orbit which it thus describes in a year shows how much it falls towards the sun during the first second of fall. This distance is known to be ·0099 foot, and this measure of the attractive energy of the sun has to be calculated at what it would be at a distance from its centre equal to 4000 miles, the earth's radius, which is only $\frac{1}{23{\cdot}984}$ of the sun's actual distance. The law by which Newton found that the intensity of gravitation varies shows that the preceding number must be multiplied by the square of 23·984, so that the mass of the sun acting on a body situated at a distance of 4000 miles from its centre will cause it to travel 5,708,763 feet or 1075 miles in the first second. The mass of the sun can therefore now be compared with that of the earth, as the action of the two masses on a body situated at the same distance from their respective centres is known; and as the mass of the sun is to that of the earth as 5,708,763 is to 16, by dividing we obtain in round numbers 355,000—that is, 355,000 globes of the same weight as our earth are required to balance the sun. In the solution of this problem it has been necessary to know the velocity of fall of a heavy body on the planet. On the earth this element is directly obtained; on planets which have satellites this velocity is deduced from the movements of these secondary bodies in their orbits round the primary planet. Where planets have no satellites the calculation of the force of gravity on them is determined by observing the influence of their masses on other planets, and the perturbations which they cause in their movements.

The phenomena of the tides have only within little more than a century been connected with the great theory of universal gravitation as the cause which produces them. Twice a day, at an interval of about twelve hours and twenty-five minutes, the shores of the ocean exhibit the phenomenon of the flow of the tide; the sea rises by degrees, encroaching on the shore, which it covers to a greater and greater height, until, after six hours' rising, it attains its maximum. The *instant of high water* or *flood tide* is no sooner attained than the *flow* ceases, and the *ebb* or return of the water commences; the sea then retires, and as gradually recedes to its point of departure, *low water* or *ebb tide*, when the tide will commence rising once more. The instant of low water is not, however, the mid-interval which separates two consecutive flood tides, the flow being of considerably shorter duration than the ebb—that is, the sea takes a longer time to go down than to rise. This difference of time varies according to the position along the coast; thus at Brest it is only sixteen minutes, while at Havre it is as much as two hours and sixteen minutes. Before going into the explanation of the causes of the tides, an examination into some of the facts connected with the rise and fall of the waters will make the matter much more simple. As there is always an interval of twelve hours twenty-five minutes between every consecutive flood tide, it follows that from one day to another high water is fifty minutes late; thus the daily period of high water will be shown to be exactly equal to the lunar day, the mean length of which is twenty-four hours and fifty minutes—that is, the successive retardations of high water occur at the successive transits of the moon over the meridian. Knowing therefore the hour of high water in a port, it becomes easy to calculate the hour for another day; and sailors, taking advantage of this fact, make their arrangements for entering or leaving a port on any particular day accordingly. This retardation of fifty minutes each day amounts in about fourteen and three-fourth days to a total retardation of twelve hours, and a retardation of twenty-four hours, or one day, in twenty-nine days twelve hours, the period of the moon's lunation, or revolution round the earth. The hours of the tides are therefore the same every fifteen days, with this difference that the morning tide becomes the evening one, and *vice versâ*, and at the end of a lunar month the hours once more become identical. Although the times of high water may be thus computed, the height of the tide itself for the same sea and the same place is very variable; but on examination this also will be found to present a regular periodicity, showing that the phenomenon is in connection with the relative positions of the sun, moon, and earth. The flood tide attains its maximum near the new and full moons, and the corresponding low water is then at its lowest point. These are the *spring tides*, and their height decreases more and more up to the time of the first and last quarters of the moon, when the *neap tides* occur. Starting again from these two periods, the height of the tide again increases until the moon is once more in conjunction or opposition. It will be found, however, that the highest tide, like the lowest, does not really fall on the same day as the lunar phase, for in every part of the ocean a difference occurs of thirty-six hours, or a day and a half. The highest tide is therefore the third tide which follows the full and new moon; the lowest tide also the third which follows the first and last quarter of the moon. Again, the height of the tides varies with the declinations of the moon and sun, and is greater as the two bodies are nearer the equator. Twice in the year, towards the 21st March and the 22nd September, the sun is actually in the equator, and if at the

same time the moon is near the same plane, the tides which then occur are the highest, the *equinoctial spring tides*, because the earth is then at the spring, or autumnal, equinox. Again, the lowest tides take place towards the solstices, the two periods when the sun reaches the northernmost and southernmost points of the ecliptic, if the moon attains its smallest or its greatest meridional height at the same time as the sun. And finally, the height of the tides is influenced by the distances of the moon and sun from the earth—the height of tide being by so much greater as the two bodies are nearer the earth; consequently the tides of the winter solstice are higher than those of the summer one. There are other circumstances which also have their influence on the tides: the force and direction of the winds, the configuration and direction of the coasts, the depth and extent of the seas—circumstances which are so many influences greatly complicating the tides. Thus in isolated seas, like the Caspian Sea, or those of small extent and communicating with the ocean by narrow straits, like the Baltic, the Black Sea, and Mediterranean Sea, the rise of the tide is almost imperceptible; *e.g.* at

		Ft.	In.
Toulon, ...	the tide rises	1	0
Antium (Porto d'Anzio, Italy),	"	1	2
Porto Rico (S. Juan), . . .	"	1	6
South Pacific, ...	"	1	8
St. Helena, ...	"	3	0

In deep estuaries or creeks, open in the direction of the tidal wave and gradually narrowing inward, the range of depth of the tide is much greater than elsewhere, as at—

	Feet.
Bristol Channel, off Chepstow, ...	70
Bay of Fundy, ...	60
Mouth of the Avon, ...	42
St. Malo, ...	40
Bristol, ...	40
Milford Haven, ...	36

The tide is felt in great rivers to a distance depending upon their size and depth. At the moment of high water the waters of the river flow back, re-ascending their course, but the advance of this river tide is progressively retarded, giving rise to the curious phenomenon known as the "bore." The rivers Severn and Ganges are examples of this. On the other hand, where promontories or headlands jut out into the sea, the tidal range is frequently small:—

	Feet.		Feet.
Wicklow, . . .	4	The Needles, . .	9
Weymouth, . . .	7	Cape Clear, . . .	11

The opposite coasts of the Atlantic, which face each other west and east, have very unequal tides. The eastern coasts of Asia have strong tides, while at the other side of the Pacific the flow, although regular, attains but little height.

The range of the tides at any particular place is also affected by certain conditions of the atmosphere. At Brest a depression of an inch in the barometer causes a difference of 16 inches in the elevation of the high-water mark; at Liverpool a depression of an inch produces a difference of about 10 inches, and at the London Docks about 7 inches; thus a low barometer produces an unusually high tide, and *vice versâ*. The influence of the wind is also frequently very considerable.

The velocity of the tidal wave is subject to considerable variation, and the laws which govern it are not at present understood. If the entire earth were uniformly covered with water, the velocity would be rather more than 1000 miles an hour ($7926 \times 3{\cdot}1416 \div 24{\cdot}8$). It is doubtful if this velocity is ever reached, unless perhaps in the Antarctic Ocean. The following table of tidal velocities is given by Whewell:—

	Miles.
In latitude 60° S., ...	670
In the Atlantic, ...	700
Azores to Cape Clear, ...	500
Cape Clear to Duncansbay Head, ...	160
Buchan Ness to Sunderland, ...	60
Scarborough to Cromer, ...	35
North Foreland to London, ...	30
London to Richmond, ...	13

The effects of tides on rivers are often remarkable. The Avon at Bristol, when the tide is out, is little more than a shallow ditch; but when the waters have risen to their maximum height, it is converted into a broad and deep channel, navigable by the largest vessels.

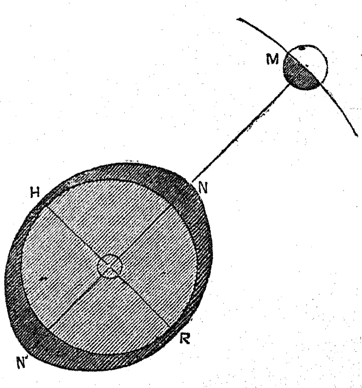
In its passage up rivers the tidal wave is gradually destroyed. Thus in the case of the Thames:—

	Height.		Distance from Mouth.
London Docks, . .	18 ft. 10 in.	...	60 miles.
Putney, ...	10 " 2 "	...	67½ "
Kew, ...	7 " 1 "	...	73 "
Richmond, . . .	3 " 10 "	...	76 "
Teddington, . . .	1 " 4½ "	...	79 "

There are certain places on the coast of Hampshire and Dorsetshire where the tide ebbs and flows *twice* in twelve hours instead of only once, as is usual. Southampton, Christchurch, Poole, Weymouth, and the Frith of Forth may be given as places where this singular phenomenon takes place.

The evident connection between the periods of the tides and those of the phases of the moon led to the tides being attributed to the moon's action long before their true theory was understood; and before Sir Isaac Newton investigated the phenomena, the explanations given were little more than vague theories. The theory of the tides may be generally explained as being that of the combined action of the moon and sun on the mass of water with which the earth is three quarters surrounded, and the attractions of which produce the alternate movements of the *ebb* and *flow*. When two bodies, such as the earth and moon, are present the molecules of both exert a mutual tendency of *gravitation*, the intensity of which varies directly as the masses and inversely as the square of the distance. The earth having the form of a spheroid, the waters which cover it would continually have exactly the same form if the moon and the sun did not exist. But the moon being present exerts an attraction, which will be understood by imagining its centre connected with the centre of the earth by an ideal line, M N′ (fig. 1); this line

Fig. 1.

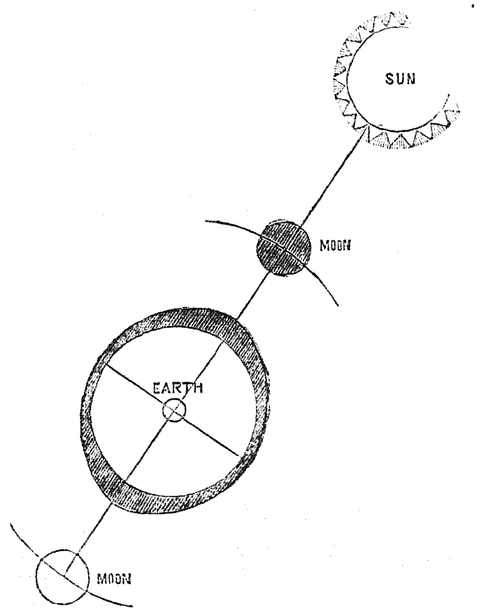


will meet the surface of the globe in two points diametrically opposite. The one nearest the moon will be the place on the earth at which the moon is in the zenith. At the opposite point the moon will be at the nadir, and every place on the earth's surface which has the same latitude as the first will see the moon on the meridian at that instant.

The attraction of the moon on the nearest liquid molecules partly counteracts the attraction of the earth, and therefore lessens their gravity in the vertical direction, and the molecules by virtue of their fluidity and independence rise by reason of this attraction; the same thing also happens, but in a less degree, with the adjacent molecules in the hemisphere turned towards the moon, the pull being slighter as the liquid molecules are situated further from the point N, which lies at the summit of the hemisphere turned towards the moon. Consequently the mass of water with which this hemisphere is covered, is heaped up towards the moon, and instead of preserving its spherical form, assumes the form of

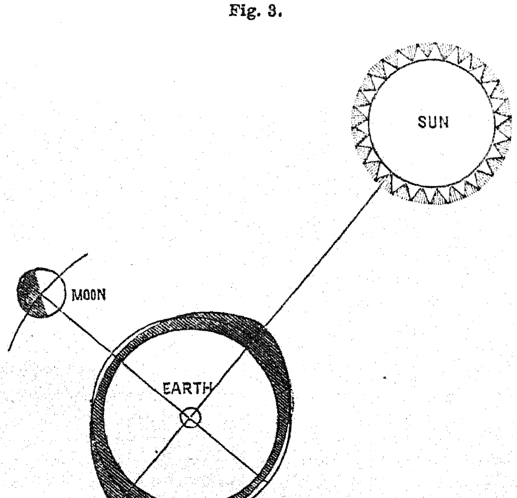
an ellipsoid; there will be high water at the position, N, nearest the moon, and low water at every place which has the moon on the horizon, H R. If the earth had no movement of rotation, this tide would be permanent, the water would remain thus in equilibrium, following the movement of revolution of the moon round the earth, and the tides would have no other period but the period of lunation. The earth in its rotation, however, presents all its surface in succession to the moon,

Fig. 2.



so that the tidal wave follows the parallel which corresponds to the position of the moon. Not only does the attraction of the moon draw together the waters on the hemisphere turned towards her, but the lunar attraction exercises an influence on all the molecules which compose the earth and the ocean, the force of which decreases as these molecules are more distant. This inequality of attraction causes the most

Fig. 3.



distant molecules to remain behind; their gravity towards the earth is diminished, and the liquid molecules on the hemisphere turned from the moon, at N′, assume precisely the same form as those at N opposite the moon; or in other words, on one side the water is pulled from the earth, on the other the earth is pulled from the water. There is therefore high water whenever the moon transits either the upper or lower meridian—that is to say, every twelve hours and twenty-five minutes; and low water every time that it is at the horizon of a place—that is to say, at periods of equal duration. In addition to the moon's attraction producing a tide, there is the attractive force of the sun. The enormous bulk of the sun would produce immense tidal movements, if its distance, 400 times greater than that of the moon, did not compensate the attractive force due to its mass. The solar tides, always much smaller than the lunar tides, sometimes increase them, at others tend to neutralize them. When the sun and moon are both on the same line with the earth (fig. 2), which occurs at new and full moon, their joint attraction increases the tides. When the sun and moon are at right angles the one to the other (fig. 3), their attractions neutralize each other, and in that case the resulting tide is a minimum. The luni-solar action is much more intense when both bodies are nearer the equator, giving rise to the great equinoctial tides. As the attraction varies in the inverse ratio of the squares of their distances from the earth, it follows that the tides are higher when the moon and sun are nearer the earth.

PENMANSHIP.—CHAPTER VII.

ANALYSIS OF THE FORMATIVE ELEMENTS OF CAPITALS CONTINUED, WITH DIRECTIONS FOR THEIR COMBINATION—EXERCISE FOR PRACTICE.

Our analysis of the "flowing grace-line capitals," given in the lower part of Plate II., extended over the six letters which occupy the first line. In all of these Hogarth's line of beauty was found imparting symmetrical grace to the different characters. On casting the eye across the second row a similar main grace-line stem will be found holding the chief place in the whole series, except in the letter J, which, among the anceint caligraphers, did not exist. The letter I was employed by the Romans to indicate both the secondary vowel I and the vocalized consonant J. The Dutch scholars finding a difficulty in suggesting the peculiar pronunciation required in certain words in which J was expressed by a consonantal sound, found it advisable, towards the close of the sixteenth century, to indicate that difference, and introduced for that purpose a hybrid letter, consisting of the upper half of an I resting upon the lower half of a Y. In all the Teutonic and Romanic languages, except Italian, this distinction of form, as indicative of a distinction of sound, has been adopted as an improvement, and in the seventeenth century it was introduced into writing and printing in England.

The two first letters in the second row are in two-thirds of their form exactly alike. Three-fourths of a lightly-made elliptical oval at the top, attached, cursively and without pause in the formation of the curve, to a down-stroke flowing main grace-line, similar to that which is seen in I, T, P, &c., constitute elements common to both. Having gone thus far the point of variation is, at the level of the base of the writing, reached. The remaining third of the letter S is then formed by the addition of a terminal oval, the method of forming which has been explained on page 547, and exemplifications of which have already occurred in each of the six preceding letters. The remaining third of the letter L is differently formed. From the point at which the grace-line terminates a sweeping horizontal grace-line is rapidly and dexterously drawn from left to right, keeping to the level of the base-line of the whole writing, and forming as it crosses the lower part of the grace-line a longish sort of loop. Great care requires to be used in the joining of this terminal to the stem grace-line at the left end of the loop, so that they may interflow delicately into one another without sharpening into an angular peak, or being rounded into an unsightly club-like boss; in the former case the horizontal line will be deficient in sweep and swell, too stiff and straight—in the latter the level grace-line will seem turgid and unbalanced in its parts. It is generally the best preparation for performing the entire process of forming these letters to practise the three elements separately till each can be readily, easily, and pleasingly made—(1) head-ovalesque ellipse; (2) stem grace-line; and (3) in S the terminal oval, in T the horizontal grace-line. Having the hand and eye thus trained to preliminary expert-

ness, the student should endeavour to join the three elementary parts together at a single sweep, placing the arm in the position which has been found to allow of the greatest freedom of movement, and keeping it in that position, making all the requisite movements from the wrist and with the fingers. Perseverance, care, and willingness to work patiently will speedily accomplish the task and complete the possession of the power of nimbly wielding the pen, and adroitly conjoining the several parts into one fair symmetrical whole.

The slightest inspection will show that the latter two-thirds of L form the main portion of D; the next part is an upward-curved line convex towards the right; and the terminal portion, which proceeds from right to left, takes almost precisely the form of the letter O, though with a slightly greater slant in its general lie than when it is written as an independent letter. This will be readily noticed by comparing that letter, the first of the fourth line, with the fourth element in D, where it commences a short distance after the right convex curved line has passed across to the left of the main grace-line. The same special caution as to the nicely-graduated interflow of the two grace-lines at their points of junction in the long loop on the left, which was given in regard to L, requires to be even more emphatically made with reference to D. Unless this looped junction is effected nicely and evenly the pleasing flow of the upward curve on the right will be injured, the upper portion will appear knobby and humphed, the junction of that curve-line with the O oval will take a sharp and peaky abruptness unpleasant to the eye, and the softness of the aspect of the whole letter will be marred by the tendency to break out into corners which the letter will present. While, possibly, one of the most beautiful combinations of the sinuous grace of the Hogarthian line, with the soft circularity of the cleverly interflowing curves, given among our alphabetical characters, D is at the same time one of the most difficult to form at once with strength of stem and sweep of curvilinear form.

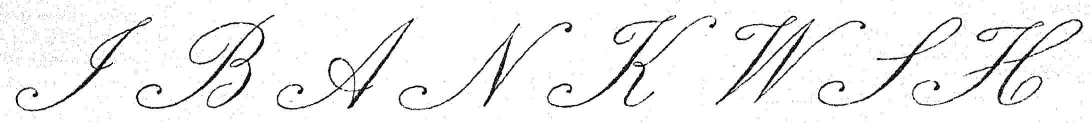
The letters H, K, V, and W have an initial form on the top at the left peculiar to themselves. It is composed of two short curved lines, one convex, the other concave, and is attached to the letter itself rather as an ornamental appendage than as a necessary part of it. It may be, and indeed often is, replaced by one or other of the initial elements marked 2 in the upper line of the connectives grouped together in the middle of Plate II. Turning attention now to the letter H by itself, we may regard it as composed of (1) an initial; (2) a down-stroke main grace-line; (3) an upward oblique grace-line; (4) a curve-line concave towards the right; and (5) a terminal ovalesque curve. The initial is formed somewhat like a slanted grace-line. After it has been properly made a down-flowing grace-line is formed. To this a thinly formed Hogarthian line is added, slanting from left to right, and extending one-third longer than the previous—*i.e.* the down-stroke grace-line. From the end of this grace-line there is to be taken a curving line, convex towards the left, crossing the oblique-going grace-line in the middle, yet about one-fifth of the whole perpendicular height of the letter distant from the first-formed grace-line, and thereafter rounding off into a simple terminal oval-ending curve. On looking at the second letter in the fourth line of the lower part of Plate II. it will be seen that the latter half of the letter H exactly corresponds in its formation with C—indeed H is often reckoned a compound character, formed by joining together T and C.

In writing K, after forming the double-curved initial element, make a main grace-line similar to that in T, and to this add (1) a thin oblique down-stroke grace-line, inclined from right to left, reaching to the middle of the letter, and making just at that point (2) a circular connective loop similar to those marked 1 in the middle line of the Plate; complete the character with a down-stroke grace-line proceeding from left to right, precisely as in the closing element of the letter R in the upper row.

After the example of the Dutch inventors J is made in the upper half exactly like I, and in the lower just in the same manner as the small letter *j*—*i.e.* with a straightish downline, curving, when due length has been given it, slightly round, and brought up as a largish loop when crossing the previous line, near the base-line of the writing.

A, N, and M have each as their first element a nicely formed oval initial on the left hand, executed as described on page 547. From that a faint, light, slanting up-stroke grace-line is taken. In the case of A a straight line is next drawn with a narrow angle from the top to the base, from which a hair-stroke connective oval is taken across the grace-line, and tapered off with a curve crossing the downward straight line. In N the second element is an almost perpendicular downward grace-line, from the base of which an up-stroke grace-line is taken, ending in a fine flowing curving terminal. In M a line somewhat similar to that made in A is brought downwards, and the latter half is a simple repetition of the two lines already formed, taking the third line from the base of writing and curving off the fourth into a slight sort of half-oval. In V we have the same initial as in H, a grace-line almost the same as that in the centre of N, and a light grace-line passing off them and ending in a curve; in fact, the latter two-thirds of N, with the initial attached, form V. Our W is, of course, V doubled, and will be found exceedingly simple.

As regards the foregoing series of seventeen flowing grace-line capitals, it may be felt that they require a little too much attention to curvilinear fluency, and perhaps a simpler form may be found desirable. It is not difficult to adapt the style of character to almost any special use. One very easy simplification we may note and exemplify as available in the case of I, T, F, P, B, R, S, K, and of A, N, M, V, W—that is, the substitution of dotted for ovalesque terminals. In the first series of letters just enumerated the dotted terminal element marked 2 in the lowest line of the middle portion of Plate II. may be used to close the main grace-line. In A, M, N (for dotted initial) that marked 1; while in K, N, V, and W the first form given in the upper line may be used as a terminal to replace the curve. The annexed specimens will sufficiently show how this substitution may be made.



We leave to the student's ingenuity to replace the curved and oval terminations in the other letters in a similar manner, well assured that a little persevering effort given to the accomplishment of the task will result in progress, pleasure, and profit.

The next series are rather more curvilinear or circular than characterized by the sinuous grace of the Hogarthian line, and are less easily described than the others. We must leave the consideration of these last nine letters for another lesson.

NATURAL PHILOSOPHY.—CHAPTER XV.

ACOUSTICS.—*Continued.*

FUNDAMENTAL TONES—OVERTONES—TIMBRE—KLANGFARBE—VIBRATION OF STRINGS—VIOLIN—ORGAN CASES—LAWS OF VIBRATING STRINGS—NODES—VENTRAL SEGMENTS—STATIONARY WAVES—STRINGS EXCITED BY TUNING-FORKS—VIBRATING RODS—WHEATSTONE'S KALEIDOPHONE—VIBRATIONS OF A ROD FREE AT BOTH ENDS—HARMONICON—VIBRATIONS OF TUNING-FORK—LONGITUDINAL VIBRATIONS OF WIRE—WHEATSTONE'S INVISIBLE CONCERT—CHLADNI'S FIGURES—NODES OF VIBRATING SQUARE PLATES—CIRCULAR DISCS—VIBRATION OF BELLS—LAW OF RESONANCE TUBES—VIBRATING COLUMN OF AIR IN WIND INSTRUMENTS AND IN PIPES—NODES IN PIPES—STOPPED PIPES—OPEN PIPES—VIBRATION OF PIPES—REED PIPES.

MOST musical instruments, when any note is sounded, as C, produce not only that tone, but also a series of other tones, each of less intensity as they ascend in pitch, riding above it. The original tone is called the *fundamental* or *primary* tone; the supplemental tones, the *harmonic* or *overtones.* If C be the fundamental tone, denoted by unity, the whole series of tone and overtones will be represented by the numbers 1, 2, 3, 4, 5, 6, 7, &c.; that is, first the fundamental tone is sounded, then its octave may be heard, then the fifth to that octave, then the second octave, then the third, fifth, and a note between the sixth and seventh to the second octave, and so on. All these overtones are subsidiary to the fundamental tone, but may be distinctly heard by a practised ear. It is the addition of these overtones to the fundamental tone that determines the quality or tone-colour of the sound. This quality of sound is termed *timbre* by the French, and by the Germans *klangfarbe*, and it is this union of high and low tones that distinguishes the sound of one musical instrument from another, as the harmonics of the one will be different from those of the other, and uniting with the fundamental tone, give rise to the variety of tone produced by various instruments. Sound in this respect closely follows the laws of light. All colour depends upon the rapidity of the vibration of the waves of light, blue bearing to red the same relation that a high note does to a low one. A simple colour has only one rate of vibration, and may be compared with a simple tone in music. Compound colours are produced by the mixing together of two or more simple ones, and tone colour is in the same way the mixing together of the fundamental and harmonic tones. The production of the fundamental tone and the overtones from the same string may be observed from the harmonics of an Eolian harp. This instrument frequently consists of a single first-violin string, either stretched at the bottom of a door which admits the passage of a current of air when the door is closed, or placed between the sashes of a window so that a current of air can impinge upon the string. When the current of air is sufficiently strong not only is the fundamental tone heard, but likewise a great variety of overtones are simultaneously produced with the most melodious effect.

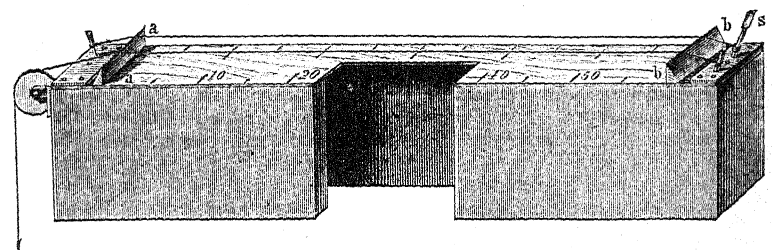
Helmholtz has analytically and synthetically investigated the nature and effect of overtones, and has been able to explain the cause of different *timbres* or qualities of sound as the result of the different intensities of the harmonics or overtones accompanying the fundamental tone. Some of these results as regards tone-colour are as follows:—Simple notes, as those produced by a tuning-fork and by a wide covered pipe, are soft and pleasant without any roughness, but feeble, and in the deeper tones dull. Musical tones accompanied by a series of harmonics, up to the sixth, are full and musical, and as compared with simple tones are grander, richer, and more sonorous. Such tones are represented by the sounds of organ pipes, harmoniums, the pianoforte, &c.

If only the uneven harmonics are present, as in the case of pianoforte strings struck in the middle, clarionets, narrow covered pipes, &c., the sound becomes indistinct, and when a greater number of harmonics are audible the sounds acquire a nasal character.

When the harmonics beyond the sixth and seventh are very distinct the sound becomes rough and sharp. If subdued in tone the harmonics are not prejudicial to the musical value of the notes, but rather impart character and expression to the music. Most stringed instruments are of this character, and pipes furnished with tongues produce sounds in which harmonics are very prominent, and acquire a peculiarly penetrating character, such as the tones yielded by brass instruments.

When a string stretched transversely between two rigid points is struck or pulled, vibrations are set up in it which depend upon the nature, the tension, and the thickness of the string, and these vibrations give rise to a musical note. The rate at which a stretched string vibrates depends upon its length, its weight, and its tension; the shorter, the tighter, and the lighter a string the more rapid its vibration. Transverse vibrations may be produced in strings by drawing a rosined bow across them, as in the case of the violin, or by plucking them with the finger, as in the case of the harp, or by striking them with a hammer, as in the case of the pianoforte. In the pianoforte and the harp there is a string for every note; in the violin several notes are obtained from the

Fig. 1.

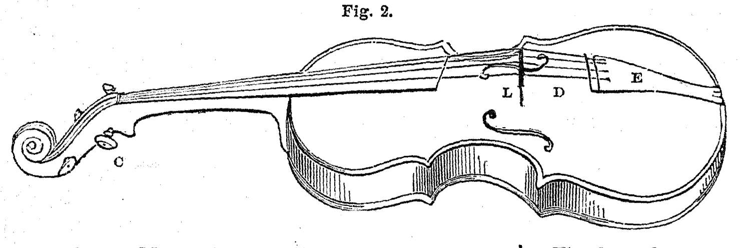


Sonometer.

same string by fingering it so as to change its length and tension. The sonometer (fig. 1) or monochord is an apparatus by which the transverse vibrations of strings may be observed. It consists of a long wooden box or soundboard, upon the upper surface of which two bridges, *a a*, *b b*, are fixed, over which the string is stretched, the tension being maintained by a weight, *c*, attached to one end of the string passing over a pulley. The two bridges on the soundboard, however, constitute the real ends of the string which vibrates between them. On the string being pulled aside at its middle, it springs back to its first position, passes it, and returns, vibrating for a time to and fro across its position of equilibrium. The sound produced does not, however, proceed from the string, the wave motion set up by so thin a body being too feeble to be heard at any distance. The vibrations of the string are communicated to the two bridges, and by them to the soundboard and to the air within the box, which takes up the vibrations of the wire, and the sound is loud and full. The importance of properly constructed sounding apparatus in stringed instruments is therefore manifest, for it is not the strings of a lute, or a harp, or a pianoforte that throw the air into sonorous vibrations, but the large surfaces with which the strings are associated and the air inclosed by these surfaces. The value of all instruments depends almost entirely upon the quality and arrangement of their soundboards. In the violin (fig. 2) the wood of which it is constructed ought to be of the most perfect elasticity. Imperfect elastic wood will expend the motion imparted to it in the friction of its molecules, converting the motion into heat instead of sound. The strings, D, of the violin pass from the tail-piece, E, over the bridge, L, to the pegs, C, the turning of which regulates the tension of the strings. The bow is drawn across at a point about one-tenth of the length of the string from the bridge. The two feet of the bridge rest upon the most elastic portion of the belly of the violin, that is, the portion between the two

f-shaped openings. One foot of the bridge is fixed over a short rod called the sound-post, which runs from the belly to the back through the interior of the violin. This foot of the bridge is therefore rigid, and it is mainly through the other foot, which is not supported, that the vibrations are conveyed to the wood of the instrument, and thence to the air within and without. The sonorous quality of the wood of a violin appears to be mellowed by age, and the continued playing upon the instrument also has a beneficial effect in constraining the molecules of the wood to conform to the requirements of the

Fig. 2.



vibrating strings. Much of the mellowness of tone of the pipes in old organs may also be ascribed to the same cause, the arrangement of the molecules forming the substance of the pipes, by usage, conforming with the vibrations set up by the columns of air contained in them. Professor Stokes' explanation of the action of sounding-boards is that although the amplitude of vibration of the board may be very small, nevertheless its larger area renders the extinction of the condensations and rarefactions of the sound-wave difficult. Therefore, with vibrating soundboards sound-waves may be generated and loud tones produced, while the vibrating strings that set them in motion, acting alone, would be almost inaudible. For the same reason the modern system of erecting organs in churches and buildings without any sufficient casework is greatly detrimental to the power and musical quality of the tone. The casework of an organ, properly carried out, becomes a soundboard by which the tones of the pipes are greatly augmented in volume and richness of effect.

When a stretched cord vibrates transversely, if l be the length of the string or vibrating portion between the two bridges of the sonometer (see fig. 1), r the radius of the string, d its density, T the tension on the string, and n the number of vibrations per second, it is found by calculation that $n = \frac{1}{2rl}\sqrt{\frac{Tg}{\pi d}}$; π being the ratio of the circumference to the diameter, and g the acceleration of gravity. From this formula the following laws are enunciated:—

I. *The tension of a string being constant, the number of vibrations in a second is inversely as the length.*

II. *The number of vibrations in a second is inversely as the diameter of the string.*

III. *The number of vibrations in a second is directly as the square root of the tension.*

IV. *The number of vibrations in a second is inversely as the square root of the density of the string.*

These laws are applied in the construction of stringed musical instruments, in which the length, diameter, tension, and material of the strings are so adjusted that given notes may be produced from them. The whole of these laws may be verified by experiment.

The relative numbers of the vibrations of the notes of the diatonic scale are—

C	D	E	F	G	A	B	c.
1	$\frac{9}{8}$	$\frac{5}{4}$	$\frac{3}{4}$	$\frac{3}{2}$	$\frac{5}{3}$	$\frac{15}{8}$	2.

If the whole length of the string on the sonometer be set vibrating, the fundamental or lowest tone of the string will be heard. By placing a movable bridge under the middle of the string it is divided into two equal parts. When either of these is set vibrating from its middle part a musical tone is produced, the octave to the fundamental tone, and this half string vibrates with twice the rapidity of the whole string. Again, one-third of the string will vibrate with three times the rapidity, producing a note a fifth above the octave; one-fourth of the string vibrates with four times the rapidity, producing a note the double octave above the fundamental tone; and as the different sections of the string, in lengths which are the inverse of the above numbers of the vibrations of the notes, are cut off by means of the bridge and successively made to vibrate, all the notes of the gamut will be successively obtained.

The law of the diameters is verified by stretching two strings of the same material on the sonometer, the diameters of which are as 3 to 2 or as 1 to 2. When the strings 3 to 2 are set vibrating the second cord gives the fifth above the other, which shows that it makes three vibrations while the other makes two; again, with the strings as 1 to 2, the thinner string will make double the number of vibrations of the other in the same time, giving the octave.

The law of tensions may be proved by stretching on the sonometer two identical strings with tensions, say, as 4 : 9. The second string will be found to give a note the fifth of the first, from which it appears that the number of their vibrations are as 2 is to 3, or as the square roots of the tensions. When the tensions are as 16 to 25 the major third or $\frac{5}{4}$ would result.

The law of densities may be determined by taking two strings of the same radius but different densities, as a platinum wire and an iron wire. These strings, although of the same length and diameter, and with the same tension, will be found to differ in the rates of their vibration. The density of iron is 7·8; that of platinum is 21·5. If d and d' are the densities of the two strings, and l and l' the lengths which vibrate in unison, then $\frac{l}{l'} = \frac{\sqrt{d}}{\sqrt{d'}}$. But as by the first law $\frac{l}{l'} = \frac{n'}{n}$, then $\frac{n}{n'} = \frac{\sqrt{d'}}{\sqrt{d}}$, which is expressed by the law of densities. Therefore a copper wire whose density is 9, and a catgut string of the density of 1, both of equal length and diameter, and with the same tension, the catgut will vibrate three times as rapidly as the copper wire. In stringed instruments, therefore, the lower tones are obtained by increased thickness in the string in place of excessive length. In the pianoforte not only are the wires thicker which produce the lower tones, but still further to reduce the number of vibrations, they are loaded with a copper wire wound spirally round them, and they therefore vibrate more slowly on account of the tension acting on a greater weight.

In connection with the laws of the transverse vibrations of strings are certain phenomena which involve mechanical explanations of a complicated nature. Let the string A C, fig. 3, be set vibrating, the ends A and C being fixed, and while vibrating let a point, B, at the centre of the vibrating string, be brought to rest by a stop; the part A B must now vibrate between A and D as a fixed point, as indicated by the loop A E D; but as all parts of the same string tend to make a vibration in the same time, the part between D C will vibrate in the same manner, as shown by D F C. If the part A B be one-third part of the string A C, the other part between B C will not perform a single vibration, but will divide into two equal parts, as in fig. 4, and vibrate in the manner shown. Again, if A B were one-fourth part of A C, the other length of the string would be subdivided into three equal vibrating parts. These points D, D′, &c., are called *nodes* or *nodal points*, and have no vibration; and the several sections of the string A C are termed the *ventral segments*. The ratio of the first of

Fig. 3.

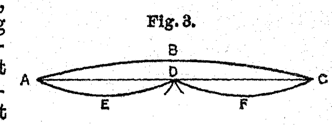
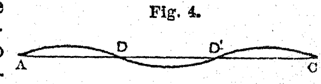


Fig. 4.

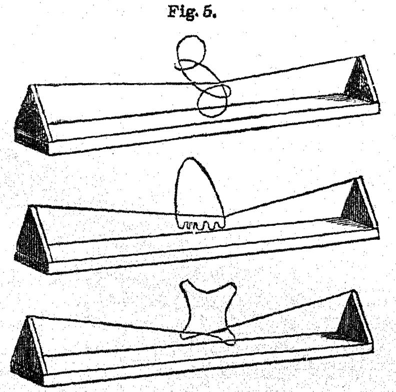


these ventral segments to the remaining portion of the string must be that of some two whole numbers, as 1 is to 1, 1 is to 2, 1 is to 3, 2 is to 3, &c. Unless this is so the nodes cannot be formed, since the two portions of the string could not vibrate in the same time, and the vibrations will interfere with and rapidly destroy one another.

The laws regulating the undulations of a vibrating string apply equally to all undulations; water waves obey these laws, and the coalescence of direct and reflected waves exhibits the same phenomena. This is illustrated by taking a long and narrow box with glass sides, partly filled with coloured water; by raising one end suddenly a wave is generated on the surface, which moves from one end to the other of the narrow space separating the glass plates. If a fresh wave is sent forward at the proper interval the surface will be divided into two stationary impulses. By making the succession of waves more rapid, the surface may be subdivided into three, four, five, or more undulations separated from each other by nodes. This is again illustrated when water is carried in a bucket. The uniform step of the water-carrier soon sets up a series of waves upon the surface of the liquid, which, unless checked, would splash over the top of the bucket. By altering his step the surface of the water is thrown into stationary waves by the change in the period of the impulses, and nodes are formed which arrest the accumulation of the motion of the first series of waves set up. The position of the nodal points in a vibrating string may be easily discovered by mechanical means. On placing small paper riders on the string, and setting the cord vibrating, all the riders on the ventral segments will be tossed off, but those across the nodes remain undisturbed. M. Melde, of Marburg, has devised another method of illustrating the same phenomena of the nodes and ventral segments in a vibrating string. A silken cord attached to one end of the prong of a large tuning-fork is so arranged as to be stretched to any required tension by means of a screw peg attached to the other end. On setting the fork vibrating the cord spreads out into a spindle form throughout its whole length. When the tension on the cord is gradually reduced, at a certain point the spindle suddenly divides into two ventral segments separated from each other by an apparently stationary node. Reducing the tension still further, the cord will divide into three or four vibrating segments separated by nodes, and this subdivision of the vibrating string may be continued to form further ventral segments separated from each other by the corresponding number of nodal points. In this experiment the prong of the tuning-fork is set vibrating in the direction of the length of the cord.

When the path followed by any point of a vibrating string is examined, so long as the vibrations are steady the point describes a straight line, but on reducing the tension slightly, so as not to alter the continuity of the vibration by the formation of a node, a number of minor motions will be superimposed upon the direct vibration of the wire, the

Fig. 5.



point then describing an infinite variety of intricate curves from the combined effect of these motions. These minor vibrations which are set up in a vibrating string in some measure account for the difference of tones which different performers will produce from the same instrument. Dr. Young examined the string of a violin when in motion, and by throwing a beam of light upon it, and marking the motion of the bright spot which it made, he found that the string rarely vibrated in the same plane, but that the middle point described various and very complicated curves, corresponding to different manners of drawing the bow. The three illustrations (fig. 5) show how greatly the vibrations produced by one player may differ from those of another. The waves proceeding from all three will be of the same length, the vibrations being performed in the same time; but the condensations and rarefactions will evidently be such as to give very different relative states to contiguous particles of air. The middle of the stretched string describes the curve on which it is placed, affecting the form of the sonorous wave, and thus influencing the *klangfarbe* or tone-colour of the sound.

VIBRATION OF RODS.

Elastic rods and narrow plates of wood, glass, and tempered steel vibrate, by virtue of their elasticity, both *longitudinally* and *transversely*, and follow the laws of vibrating strings. A rod fixed at both ends will vibrate as a whole (fig. 6), and will also divide itself into two vibrating parts, (fig. 7), or three or more parts (fig. 8), but the laws which regulate the pitch of the successive tones are different from those of vibrating strings. When a string divides itself into two parts, each of the halves vibrate with twice the rapidity of the whole string, producing the octave tone to the fundamental note. In the case of vibrating rods, each of the half ventral segments vibrates with nearly three times the rapidity of the whole rod, or in the ratio of 9 to 25—that is, as the square of 3 to the square of 5. Thus, taking the number of nodes in the figures as 0, 1, 2, the number of vibrations are 9, 25, 49; and if there were 3 and 4 nodes, &c., the number of vibrations would be 81 and 121 respectively, which represent the squares of the odd numbers 3, 5, 7, 9, 11, &c.

Fig. 6.

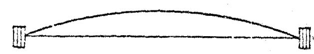


Fig. 7.

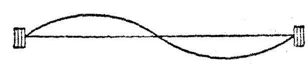
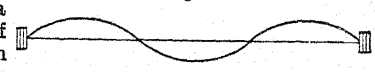


Fig. 8.



The laws regulating the vibrations of elastic rods were first determined by Leonhard Euler, the geometrician of Basel, in 1741, and are contained in the formula $N = \frac{n^2 e}{l^2}\sqrt{\frac{qr}{\delta}}$ in which N represents the number of vibrations per second, e the thickness of the rod in the direction of its vibrations, δ its density, r its elasticity, and n a constant which has reference to the mode in which the rod is fixed and the number of nodes formed.

This formula demonstrates that (1) *the number of vibrations of a rod are independent of its breadth*; (2) *they are proportional to the thickness of the rod*; (3) *they are in the inverse ratio to the square of the length of the rod*; (4) *and are inversely as the square root of the density of the rod.* When a rod is fixed at one end and left free at the other, it is the elasticity of the material, and not any external tension, that maintains the vibrations. If a rod fixed at one end (fig. 9) is pulled aside and then liberated, it will vibrate as a whole. But it is capable of other modes of vibration: by damping it at a point in its length with the finger and again striking the rod smartly between the finger and its point of attachment, the vibrations of the rod will divide into two parts, separated by a node at the point of damping by the finger (fig. 10). In this case the rod, besides oscillating in the segments, oscillates as a whole, the segmental oscillations being superposed upon the fundamental vibration. The amplitude of the segmental vibrations depends upon the

Fig. 9.

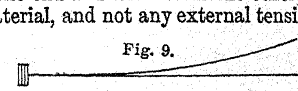
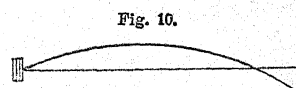


Fig. 10.



character of the blow; when that is sluggish, the minor oscillations are feeble as compared with the whole oscillation; but when a smart blow is given the ventral vibrations are vigorous, and the whole oscillation of the rod is feeble. Musical instruments are frequently constructed upon the principles of the longitudinal vibrations of elastic rods. Chladni constructed a harp upon this principle. It consisted of a series of twenty thin deal rods, some coloured white and others red, fixed at one end into a solid wooden pedestal. The lengths of the white rods were adjusted to give the notes of the diatonic scale, and the semitones were given by the red-coloured rods, completing the chromatic scale; on rubbing the rods in the direction of their length, between the finger and thumb, previously covered with powdered resin, tones resembling those from a pandean pipe were produced. The *tuning-fork*, the *triangle*, and the *musical box* are examples of the transverse vibrations of rods. In musical boxes, small bars of steel of different dimensions are fixed upon a steel plate, like the teeth of a comb. A cylinder, whose axis is parallel to this rod, and the surface of which is studded with steel pins arranged in the required order, is placed near the extremities of the steel bars. When the cylinder is set in motion by clockwork, the pins striking the steel bars set them in vibration, producing a musical succession and combination of notes.

The vibrations of the steel bars, and consequently their pitch, are determined by their length and strength, so that the proper musical note is produced from each one. Wheatstone devised a simple method of studying the vibrations of rods fixed at one end. Attaching a small silvered glass bead to the free end of a rod, and allowing light from the sun or a lamp to fall upon the bead, a small point became intensely illuminated. On vibrating the rod, the brilliant line described by this point indicated the character of the vibration. In his instrument, which he termed a *kaleidophone*, the fixed end of the rod remaining stationary, he combined on the rapid vibratory motion given to the rod by mechanical means a direct and transverse motion of its axis, which could be varied in different ratios. By this means he obtained an almost infinite variety of luminous scrolls of the greatest intricacy and beauty. By employing two candles, producing two spots of light, each of which described its own luminous line, the scrolls became doubled. An ordinary long knitting needle fixed in a vice or block of wood, with a small bead attached to the free end, and set vibrating by the finger, illustrates these scroll patterns very beautifully. When the needle is first set vibrating the spot describes a ribbon of light which speedily opens out into an ellipse, passing into a circle, and again through a second ellipse back to a straight line. This curve is due to the combinations of the two rectangular vibrations. By setting the knitting needle vibrating so as to form nodes, a variety of scroll patterns will be traced by the luminous bead.

Chladni has determined experimentally the vibrations of a rod free at both ends. Taking a flexible wooden rod, about 6 feet long, and holding the two ends by the thumb and finger some 12 inches from the extremities, on striking the rod in the middle, it vibrates the central segment in the form of a spindle, the two ends spreading out as fans. It is found that the two nodes thus formed are distant from the end of the rod about one-fourth of the distance between the two nodes. The rod may be set vibrating in four parts, divided by three nodes. The fundamental tone of a rod free at both ends is higher than the fundamental tone of a rod of the same length fixed at one end in the proportion of 4 to 25. The rates of vibration in a free rod rise with the number of nodes in the following proportion:

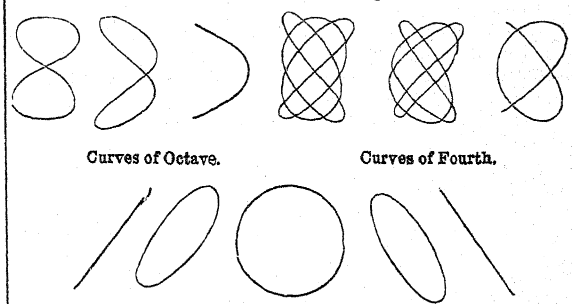
Number of nodes, ...	2	3	4	5	6	7
Numbers, the square of which is proportional approximately to pitch, ...	3	5	7	9	11	13

For musical instruments the first division of nodes in a free rod is generally employed. The French *claque-bois*, which consists of bars of wood resting at their nodes on a cord, and struck by a hammer, is of this class. The tones produced are very agreeable, and it is often introduced in operatic music to represent bells. When strips of glass or metal bars are employed, the instrument is familiar as the *harmonicon*. The tuning-fork is virtually a bar free at both ends set vibrating. This is apparent if a straight steel bar be set vibrating with its nodal points corresponding to the mode of division in fig. 11. If both ends of the bar be bent slightly upwards, the two nodal points still remain, but will have approached nearer to each other, and the note produced by the vibrations of the bar is somewhat lower than that of the straight bar.

Fig. 11.

The bar may be successively bent upwards until the ends form the tuning-fork, with the arms parallel to one another. The two nodal points still remain, but are much nearer together than when the bar was straight. When the tuning-fork sounds its fundamental note, the prongs oscillate between certain limits, and the two nodes will be found at the bottom of the arms, where they unite with the bend. Overtones may be superposed upon the fundamental tone of a tuning-fork, and in passing from the fundamental to the first overtone, the interval is much greater than that between the fundamental and the first overtone of a vibrating string (fig. 12). Two tuning-forks may have their

Fig. 12.—Vibrations of Tuning Forks.



Curves of Unison.

fundamental tones in perfect unison, but when the first overtones of both are sounded they may not be in unison, and rapid "beats" will be perceived; by loading one of the forks, the two overtones may be brought into unison, but the fundamental tones will then produce loud beats when sounded together. When the overtones of each fork are produced by vibrations $6\frac{1}{4}$ times as rapid as the vibrations of the fundamental, the forks are in perfect accord. Helmholtz, who examined a series of forks, found that the first overtone varied from 5·8 to 6·6 times that of the fundamental. The rates of vibration of the whole series of overtones of the tuning-fork are as the squares of the numbers 3, 5, 7, 9, 11, &c., or the first overtone requires to execute 9 vibrations in the same time that the second executes 25, the third 49, the fourth 81, the fifth 121, and so on. The overtones of the tuning-fork rise with greater rapidity than those of a string, and they also vanish more rapidly, and affect the purity of the fundamental tone to a less extent.

Every string under tension is capable of vibrating in the direction of its length, as well as executing transverse vibrations; but when the string vibrates in the direction of its length, it is not by external tension, but by the elastic force of the molecules of which it is composed. This molecular force of elasticity is much greater than the force of tension, and therefore the sounds produced by the *longitudinal vibrations* of a string are more acute than those produced by its transverse vibrations. Longitudinal vibration may be excited by passing briskly along the string a piece of leather on which powdered resin has been sprinkled. On pulling aside the wire of a monochord, the sound is produced by the transverse vibrations of the string; but when the resined leather is rubbed along the wire, the note produced is much more piercing. In longitudinal as well as transverse vibrations the number of vibrations executed in a given time is inversely proportional to the length of the wire. The tone produced by the longitudinal vibrations of a wire is inde-

pendent of the amount of tension. When two wires of iron and brass, of the same length and thickness, vibrate together longitudinally, the tones produced will not be the same, the notes from the iron wire being considerably higher, because the velocity of the sound-wave in iron is greater than in brass. The sound-pulses pass to and fro from end to end of the wire; at one moment the wire strives to push forward its end, at the next moment it pulls it in the opposite direction; this pushing and pulling is due to the passage of the pulse to and fro along the whole wire, and the time required for a pulse to traverse the whole wire and back again is that of a complete vibration; the pitch of the note depends upon the velocity with which the sound-pulse is transmitted through the wire. In order that the brass wire shall sound the same note it requires to be shortened, so that the sound-pulse shall traverse both wires in precisely the same interval of time; if the iron wire is 23 feet long, the length of the brass wire must be 15 feet 6 inches, or in the ratio of 11 : 17, which numbers express the relative velocities of sound in brass and iron, being in the former 11,000 feet, and in the latter 17,000 feet a second. The rates of vibration of the ventral segments of a wire vibrating longitudinally follow the order of the numbers 1, 2, 3, 4, 5, 6, &c., and correspond to those of a wire vibrating transversely. A rod or bar of metal or wood, with its two ends fixed and vibrating longitudinally, divides itself in the same manner as the wire, and the succession of tones is likewise the same in both.

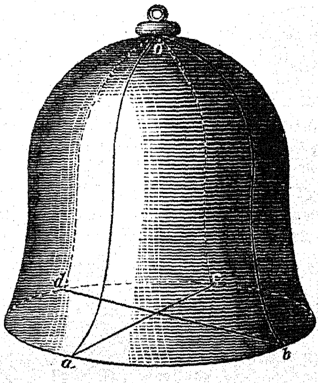
Wheatstone's investigations into the longitudinal vibrations of rods and solid conductors suggested to him an exceedingly beautiful series of experiments illustrating the transmission of musical sounds through wooden rods. His first conception was most startling. At King's College Laboratory, London, he suspended a gilt lyre over the doorway, and on the passing beneath the door of an august personage visiting the laboratory, the suspended lyre sent forth the strains of the National Anthem from its apparently silent strings. Shortly afterwards, at the Polytechnic Institution, Regent Street, Wheatstone introduced to the public his invisible concert. The audience, on entering the music room, beheld on the orchestra platform a grand pianoforte, a harp, two violins, and a violoncello, and music stools placed before each instrument, but no performers. At a given signal invisible fingers seemed to sweep over the strings of the harp and violins, run scales and rapid passages over the notes of the piano, and a concerted piece of music was performed before the astonished audience. In these experiments the vibrations from the soundboard of a distant instrument are conveyed, by a wooden rod resting on the soundboard, to the soundboard of the corresponding instrument with which the other end of the rod is in contact. This rod faithfully delivers up the vibrations of which it is the vehicle. The soundboard of the receiving instrument transferring the motion to the air, sonorous waves are produced, and the musical tones reach the ear. The performers are seated at the distant instruments, and the wooden rods transmit the vibrations they produce. If any instrument is removed from contact with the rod, the sound instantly ceases, but upon contact being restored the instrument becomes again musical.

Chladni in 1785 was the first experimenter who rendered sonorous vibrations visible by means of sand strewn upon the surface of a vibrating body. He employed a round plate of glass fixed at its middle (Plate XIV., fig. 1). A little fine sand was spread on the surface, and the plate was set vibrating by a bow, when the sand assumed the form of a star, with six or eight rays. A plate intended to vibrate is fixed in the centre, and a bow is drawn rapidly across one of the edges, or it may be fixed at any point of its surface, and caused to vibrate either by the bow or by rapidly drawing a resined string against the edges of a central hole. All vibrating plates contain nodal lines, which vary in number and position according to the form of the plates, their elasticity, the mode of excitation, and the number of vibrations. Taking a square plate of glass over which fine sand has been scattered, and damping the middle point of one of its sides by touching it with the finger, while a bow is drawn across the edge of the plate near one of its corners, the sand leaves the vibrating parts and accumulates on the two nodal lines which divide the square into four smaller ones (fig. 2). This division of the plate corresponds to its lowest or fundamental tone. The signs + and − denote that the two squares are always moving in opposite directions, and that when the squares marked + are above the average surface of the plate those marked − are below it. And the reverse takes place when the squares marked − are above it; then those marked + are below it. The nodal lines indicate the boundaries of these opposing motions, and being the places of transition from the one motion to the other, remain perfectly quiescent. When the plate is damped at one corner and set vibrating by passing the bow across the middle of one of its sides, the sand leaves the vibrating parts and accumulates in two well-defined ridges along its diagonals (fig. 3). The note produced is the fifth above the fundamental. The position of the nodal lines may be determined by damping the points at which it is desired to produce them. Their number increases with the number of vibrations or the higher the pitch of the note produced. The nodal lines possess great symmetry of form, and the same pattern is always produced on the same plate under the same conditions. The examples given in the Plate (figs. 2 and 3) show some of the great variety of figures produced by the nodal lines of vibrating square plates.

The vibrations of circular plates likewise produce a series of beautiful nodal lines. If a disc of brass is supported horizontally upon an upright stand, the disc is capable of dividing itself into numerous vibrating parts, and of emitting sounds of various pitch. By touching the edge and drawing a bow across the edge at a point 45 degrees distant, the nodal lines form four quadrants, ranged along two diameters, and the note is the fundamental. By drawing the bow 30 degrees distant from the damping point the disc resolves itself into six vibrating segments (Plate XIV., fig. 1), and the nodal lines arrange themselves in a star. By again setting the disc vibrating at a point still nearer the damping point eight segments are formed. In this way the disc may be divided into fourteen or sixteen segments, the number of segments being always an even one. The greater the number of divisions the more rapid the vibrations and the higher the pitch of the note. By leaving the centre of the disc free to vibrate and damping various points of the surface, nodal circles and other curved lines are obtained. Various forms of nodal lines produced from the vibration of circular plates are given (fig. 4). The vibrations of plates are governed by the following law:—*In plates of the same kind and form, and giving the same system of nodal lines, the number of vibrations in a second is directly as the thickness of the plates, and inversely as their area.* Gongs and cymbals are examples of musical instruments in which the sounds are produced by the vibration of metal plates.

Membranes, from their flexibility, cannot vibrate unless they are stretched, like the skin of a drum. The sound they produce is more acute in proportion as they are smaller and more tightly stretched. In the drum the skins are stretched on the ends of a cylindrical box. When one end is struck the vibrations set up are communicated to the internal column of air, by which the sound is considerably augmented. Membranes either vibrate by direct percussion, as in the drum, or they may be set in vibration by the vibrations of the air, provided these vibrations are sufficiently intense. Membranes very readily take up the vibrations of the air on account of their small mass, their large surface, and the readiness with which they subdivide.

Fig. 13.



The vibrating segments and nodes of a bell are similar to

those of a disc. On emitting its deepest tone it divides into four vibrating segments, by four nodal lines, *a*, *b*, *c*, *d* (fig. 13), running up from the sound-bow to the crown of the bell, *o*. The blow of the clapper is always the middle of a segment. In the vibrations of a bell the ring forming the sound-bow at one moment assumes an oval form, at the next moment the longest diameter becomes the shortest, and the oval is at right angles to this axis, and these changes from one oval to the other constitute the vibrations of the bell. The four points where the two ovals intersect one another are the four nodes. The number of vibrations by a bell in a given time varies directly as the thickness and inversely as the square of the diameter of the bell. The sound-bow of the bell can divide itself into any even number of segments, after the manner of a vibrating disc. Starting with the fundamental tone, the number of vibrations corresponding to the respective divisions of a bell is as follows:—

Divisions, ...	4 . 6 . 8 . 10 . 12
Numbers, the squares of which give the vibrations, ...	2 . 3 . 4 . 5 . 6

If the sides of the bell be thin the tendency to subdivision is increased to such an extent that the admixture of the overtones destroys to a great extent the purity of the fundamental tone. The absence of uniformity in the thickness round the sound-bow of bells produces that intermittent sound frequently observed when their tones are dying out. This arises from the combination of two distinct rates of vibration having their origin in this absence of uniformity. In a vibrating bell there are no points of absolute rest, for the nodes of the higher tones differ from those of the fundamental; and the various parts of the sound-bow, even when the fundamental tone predominates, vibrate with very different degrees of intensity, but as they are all dependent the one upon the other, they compensate themselves to a great extent.

When a tuning-fork, the rate of vibration of which has been determined by the syren, is held over a glass jar (fig. 5, Plate XIV.) and set vibrating, the sound of the fork is scarcely audible. Keeping the fork in position while water is poured into the jar so as to shorten the column of air underneath the fork, the sound augments in intensity as the water rises in the jar, and when the water reaches a certain level the maximum sound of the fork is obtained, which will again decrease as the water rises in the tube beyond this point, until at last it becomes inaudible. It will be found by experiment that there is a certain length of air column which produces a maximum augmentation of sound in relation to the number of vibrations or pitch of a tuning-fork. This reinforcement of the sound is the result of *resonance*. The length of the column of air becomes smaller as the rapidity of vibration increases. The law which determines this length is as follows:—*The length of the column of air* which resounds to the vibrations of a tuning-fork *is equal to one-fourth of the length of the sound-wave produced by the fork*. By employing little hollow spheres Helmholtz was enabled to analyze composite sounds. These small spheres, which he called *resonators*, were furnished with a small projecting orifice on one side, which being inserted into the ear, while the sound-wave entered the hollow sphere through a wide aperture on the other side, had the effect of greatly augmenting the power of a particular note of a composite sound by the resonance of the cavity of the sphere, and it was thus in a measure isolated from the other harmonics, and could be studied alone.

In the sounds resulting from the vibrations of solid bodies the air serves only as a vehicle for their transmission. In wind instruments, on the contrary, when the sides of the tube are of adequate thickness, the inclosed column of air is the sounding body, and the substance of the tube is without influence on the fundamental note. With equal dimensions it is the same whether the tubes are of glass, of metal, or of wood. These different materials, however, give rise to different harmonics, which, blending with the fundamental note, impart a very different quality to the compound tone produced. The consideration of the subject of *organ pipes* is one of great importance. Wind instruments are divided into *mouth* instruments and *reed* instruments, according to the manner in which the air within the tubes is made to vibrate. In mouth instruments all parts of the mouthpiece are fixed, as in the mouthpiece of an organ-pipe, a whistle, or of a flageolet. In reed instruments the column of air is set in motion by the vibration of an elastic tongue, as in the clarionet, bassoon, and the hautbois. The simplest form of a reed instrument is that of the Jew's harp.

When a current of air is directed across the open end of a tube (as in fig. 6, Plate XIV.), an infinity of pulses at the open mouth of the tube are generated, one of which, being in synchronism with the column of air in the tube, causes it to vibrate, and a musical note is produced. When different tubes are compared the rate of vibration is found to be inversely proportional to the length of the tube. Thus three tubes of 24, 12, and 6 inches long will give the fundamental note, the octave, and the double octave of the fundamental.

The vibrations of the air producing a musical note take place in a direction *parallel* to the axis of the pipe, and not transversely, as in the case of the segments of a vibrating string; in both cases, however, *nodes* and *loops* or segments may be produced. In a sounding-pipe the *node* is a section of the column of air contained within the pipe, where the particles remain at rest, but where there are rapid alternations of condensation and rarefaction. The *loop* or *ventral segment* is a section of the column of air contained in the pipe, where the vibrations of the particles of air have the greatest amplitudes, and where there is no change of density. The sections of the column of air are made at right angles to its axis. When the column of air is divided into several vibrating segments the distance between any two consecutive segments is constant, and it is bisected by a node. When a tube is sounded to produce the fundamental tone, if the strength of the current of air is augmented, a tone is obtained of much higher pitch than the fundamental note. This is the first overtone of the tube, to produce which the column of air has divided itself into two vibrating segments with a node between them. By again increasing the blast a still higher note is produced, the column of air within the tube being divided into three vibrating segments, separated from each other by two nodes. In the case of a stopped pipe, that is, a pipe closed at the top, the bottom is always a node, for the stratum of air in contact with it is necessarily at rest, and only undergoes variations of density. At the mouthpiece, on the contrary, where the air has a constant density, that of the atmosphere, and the vibration is at its maximum, there is always a segment. In any stopped pipe there must be at least one node and one segment; the pipe then sounds its fundamental note, the column is undivided, and the pulse simply moves up and down the pipe from top to bottom, each distance up or down being equal to half a wave-length. When the pipe sounds its first overtone the pulses of the two vibrating segments abut against the one node, from which they are reflected as from a fixed surface. This nodal surface is situated at one-third the length of the pipe from the mouth. In the second overtone, where there are two nodal surfaces formed in the column of air in the pipe, the first is at one-fifth of the length of the pipe from its mouth, the remaining four-fifths being divided into two equal parts by the second nodal surface. The *Pan pipe* consists of a series of single stopped tubes of different lengths put together so as to form the diatonic scale. The successive divisions into ventral segments, and the relation of the overtones in the column of air of a stopped pipe, are identical with those of a vibrating rod fixed at one end.

Stopped or covered pipes in the organ are such as have their top closed by a stopper or plug (Plate XIV, fig. 7). Pipes of this description are much used in all organs; they are made either of wood or metal. Half-stopped pipes are those which have in the stopper a small tube or chimney (fig. 8). The name *Rohr* (reed or hollow pipe) is applied to them; the tone of these pipes is very smooth and liquid. The tone of a stopped pipe is about an octave deeper than an open pipe of the same length, because the sound-pulse in the body of the pipe, when the column of air is in vibration, instead of escaping at the top, is checked by the stopper, and returns down the pipe to the mouth to make its exit.

It thus travels the length of the pipe twice over, first up, then down, and produces consequently a sound of increased gravity. The CC note, or 8 feet tone, is therefore produced from a stopped pipe of 4 feet in length, and a stopped pipe of 8 feet produces the 16 feet tone.

Since the length of a stopped pipe sounding its fundamental note is one-fourth of the length of its sonorous wave, the length of an open pipe is one-half that of the sonorous wave it produces. There are various ways of agitating the air at the ends of pipes and tubes so as to throw the air-columns within them into vibration. In organ-pipes this is accomplished by discharging a thin sheet of air against a sharp edge. (See Plate, figs. 9, 10, 11). The mouth is that part where the body is joined to the foot or bottom part of the pipe, which is of an inverted conical shape, tapering from the mouth downwards; above and below are two edges called the lips, formed by flattening a portion of the pipe and the foot where they are joined together; a small portion of this flattened part is cut away, leaving a long opening, the edge of which on the pipe is called the upper lip, and the corresponding part on the foot, the under lip. Between the lips is a flat piece of metal called the languid; this is made thick and strong, and between the languid and the lips is a narrow slit or windway for the current of air to pass into the body of the pipe from the small hole at the bottom of the foot. The shape of the languid is shown in fig. 10; it is firmly soldered horizontally at the top of the foot just inside the mouth. The size and proportion of the mouth greatly influence the quality, character, and strength of the tone. A wide high-cut mouth gives a round powerful tone; a narrow mouth a more acute tone; a narrow low mouth a delicate tone; and if the mouth is very wide and high, the tone is hollow and less clear. There are, however, limits to these variations, for if the mouth is too narrow the pipe will speak an octave above the fundamental tone; and if the upper lip is cut up too high, the pipe will either be slow in speaking, or will not sound at all. The musical tone of the pipe is produced by the air rushing through the windway; there the stream of air divides, one part going out of the pipe into space; the other part strikes against the upper lip, and this concussion causes the column of air in the body of the pipe to vibrate; thus the tone is produced in both wood and metal pipes, as shown in the section of flue pipe (fig. 12).

The condition of the air within an open organ pipe, when the fundamental note is sounded, is that of a rod free at both ends, held at its centre and caused to vibrate longitudinally. When the fundamental note is produced there will be a segment at each end, since the inclosed column of air is in contact with the external air at those points, and a node at the middle section of the pipe, the node and segments dividing the column into two equal parts. When the first overtone is produced, there will be a segment at each end and a segment in the middle, the column being divided into four equal parts by the alternate segments and nodes. When the second overtone is produced, the column of air will be divided into six equal parts by the alternate segments and nodes, and so on. It will be thus seen that the successive nodes of division of the vibrating column are the only ones that permit the alternate recurrence at equal intervals of nodes and segments, and with the occurrence of a segment at each end of the pipe. An open pipe sounding its fundamental note divides itself into two semi-ventral segments separated by a node. This may be observed by constructing a wooden organ pipe with one of its sides of glass, through which can be seen the position of any body within it. If a little hoop is covered with a very thin stretched membrane, and lowered into the pipe by means of a string, when held above the upper end of the pipe the vibration of the column of air in the upper segment of the pipe sets the membrane buzzing. When lowered into the pipe this buzzing continues for a time, the sound gradually becoming weaker, and finally ceasing. This takes place in the middle of the pipe, where it cannot vibrate, because the air around it is at rest on the nodal line. Lowering the membrane still further the buzzing sound instantly recommences, and continues down to the bottom of the pipe. Thus, as the membrane is raised and lowered, there are two periods of sound, separated from each other by one of silence for every ascent and descent. At this central node, where the pulses of air meet, compression is produced, and as they recoil rarefaction is set up, so that while at the node of an organ pipe there is no vibration, the air there undergoes the greatest changes of density. At the two ends of the pipe, on the other hand, the air particles merely swing up and down without apparent compression or rarefaction. Another mode of illustrating the position of the nodes is to construct a pipe with holes bored in one of its sides, the holes being covered by little swinging flaps, which can be opened and shut as required. When all the flaps are closed, if the pipe is arranged to produce a note by which the nodes are opposite certain of the flaps, and the segments at others, at these latter points the density of the internal air is that of the external air, and consequently if one of the flaps at these points is opened no change is produced in the note. At the former points, opposite the nodes, condensation and rarefaction are alternately taking place. If one of these doors is opened this alteration of density is no longer possible, for the density at this open point must be the same as that of the external air, and consequently this hole becomes a segment, and the note sounded by the pipe is changed. The change of notes produced by changing the fingering of the flute, is one application of this experiment.

The column of air in *stopped pipes* is always divided by the nodes and segments into an *uneven* number of parts, which are equal to each other, and in each of which is a quarter of a complete vibration, while in an *open pipe* it is divided into an *even* number of such parts. If L be the length of the pipe, l the wave-length of the note which it produces, and p any whole number, then for stopped pipes $L=(2p+1)\frac{l}{4}$; and for open pipes $L=2p\frac{l}{4}=\frac{pl}{2}$. Replacing in each of these formulæ l by its value $\frac{v}{n}$, in which v is the velocity of sound, and n the number of vibrations in a second, then $L=(2p+1)\frac{v}{4n}$ and $L=\frac{pv}{2n}$; from which for stopped pipes $n=\frac{(2p+1)v}{4L}$, and for open pipes $n=\frac{pv}{2L}$. If in the formula for stopped pipes, p represents the successive values 0, 1, 2, 3, 4, &c., then $n=\frac{v}{4L}, \frac{3v}{4L}, \frac{5v}{4L}$, that is, the fundamental sound and all its uneven overtones; and in the formula for the open pipe, similarly $\frac{v}{2L}, \frac{2v}{2L}, \frac{3v}{2L}$, &c., that is, the fundamental sound and all its overtones, even and uneven.

The *syren* (described in page 604) produces musical tones by subdividing a column of air into a series of minute puffs, and the action of the reed in an organ pipe, or when employed in the concertina, accordion, harmonium, and such like musical instruments, is exactly the same. The reed itself does not emit any sound, but by its rapid vibration, opening and closing the air passage into the pipe or sounding chamber, subdivides the column of air passing into the pipe or chamber into minute puffs, and it is the rapid subdivision of the column of air, and the vibrations thereby set up, that produce the musical tone of reed pipes and reed instruments. The reeds in an organ-pipe either control or are controlled by the vibrations of the column of air. In the former case they are comparatively stiff, as in the reeds of the pedal stops and other similar pipes, and the column of air set vibrating is of such a length that either its fundamental tone or one of its overtones shall assimilate with the rate of vibration of the reed. In the latter case the reed is more flexible, and yields to the vibrations of the air. The construction of a reed pipe is shown at fig. 13, Plate XIV. The *tube* or body of the pipe is either cylindrical, an inverted cone, an inverted cone with a bell mouth (fig. 14), an inverted cone with a bell and truncated cone mouth (fig. 15), or an inverted wood pyramid. The tube rests upon a *block*, to which it is soldered, in

small metal pipes; but in the larger pipes it slips into a socket or *boot*, which holds it firmly and steadily. In the block are two holes, one of which receives the *reed*, which is a small cylindrical brass tube, with an opening as though a portion of one side were cut away. It is generally a little wider at one end than the other, and is closed at the lower end. The *tongue* is placed immediately over the opening in the reed, and is fastened to the block by a small wood or metal wedge. The smaller hole in the block admits the *tuning-wire;* the lower end of this wire is bent, and presses firmly on the tongue, as shown in figs. 15 and 16. The boot supports the entire weight of the pipe, and rests upon the soundboard, from which it receives the wind through a hole, s, in the latter. In producing the tone, the tongue, which is slightly curved, *strikes against* the reed, and the *pitch* of the note is regulated by the tuning-wire, which is hooked at the upper end, so that the tuning-knife may the more readily move it upwards or downwards, shortening or lengthening the fulcrum of the tongue. When the reed is *open* all the way up, it is called an *open reed;* when the space in the reed is partially covered or closed, it is called a *closed reed.* A third kind of reed is called the *free reed.* In this reed the tongue vibrates alternately before and behind the opening in the reed, and just escapes grazing the edges. This form of reed is chiefly employed in the harmonium, concertina, accordion, &c., and is of recent invention. The tone of the *open reed* is full, rich, and sonorous. In very large pipes, such as the 32-feet reeds on the pedal organ, the edges of the open reed are sometimes covered with leather, to prevent the tone being too rough and rattling. The *closed reed* produces a more subdued tone than the open reed, but is less dignified in character. The tone of the *free reed* is exceedingly smooth and musical, but is wanting in vigour, and has no carrying power. It is from this cause that harmoniums, although sounding full and loud in a small chamber, are unsuited for churches and large buildings. The musical speech of a reed pipe is caused by the pressure of wind on the tongue compressing it against the reed, and thus for the instant cutting off the wind from entering the pipe; the elasticity of the tongue restores it to its original position, and for the instant the wind enters the pipe, but compression again taking place it is once more cut off. The pulsation of the tongue against the reed therefore sets up a series of rapid vibrations in the column of air in the pipe, and the musical tone is produced. The *quality* of the tone is influenced by the form, scale, and material of the tube. Short cylindrical pipes, as the *clarionet* or *vox humana*, give a comparatively light sound; tubes of the inverted conical shape are more sonorous, and the strength and character of the tone depends upon the *scale* and length of the tube. When the tube is of small scale the tone is thin and nasal, as in the *bassoon* stops. If to a narrow tube a bell is added the tone is clear, but of a wailing character, as in the *oboe* stop. When a larger scale is employed, weight and power of tone are obtained, as in the *trumpet;* an additional scale produces the ponderous tone of the *posaune*. The quality of the tone likewise is greatly influenced by the shape of the opening of the reed, and the smoothness and flatness of its edges, upon the thickness of the tongue, its curvature, and the metal employed, whether brass or an admixture of copper and brass. The tongues of the clarionet, oboe, and bassoon are long, thin, and narrow; those of the trumpet, horn, trombone, posaune, &c., are shorter, thicker, and broader. In instruments such as the hautbois, the clarionet, &c., the reeds are *mouth* reeds. The clarionet is simply a reed pipe, in which a long cylindrical pipe is associated with a single broad tongue. The reed end of the pipe is placed between the lips, and by their pressure the slit between the reed and the tongue placed over it, is narrowed to the extent required to set the tongue vibrating. The overtones of the clarionet are different from those of the flute. The flute is an open pipe, the clarionet a stopped pipe, the reed answering to the closed end. Wheatstone was the first to point out this difference; the tones of the flute follow the order of the natural numbers, 1, 2, 3, 4, 5, &c., or of the even numbers, 2, 4, 6, 8, 10, &c.; while the tones of the clarionet follow the order of the odd numbers, 1, 3, 5, 7, 9, &c. In the hautbois and bassoon two reeds incline to each other at a sharp angle, the wind being urged through the slit between them. The hautbois has a conical tube, and its overtones are those of an open pipe, and different from those of the clarionet. In the horn, trumpet, cornet-à-piston, and serpent, the lips of the player form the reed; as these instruments are constructed with long conical tubes, their overtones are the same as those of an open organ pipe. These instruments being furnished with keys between the spaces of the successive overtones, the performer is enabled to vary the length of the vibrating column of air.

The organ, as a whole, constitutes the most perfect acoustical musical instrument in existence. All wind instruments may be referred to the different types of sounding tubes used in the organ.

LOGIC.—CHAPTER VII.

INDUCTION—INVESTIGATIVE OBSERVATION—PREPARATION OF PROPOSITIONS FOR SYLLOGISTIC PURPOSES.

The syllogism is the type of reasoned thought, the form it assumes in normal operations. The form is technically spoken of as "a mere empty form" unless it is filled with something thought about. The thing and the thinking ought to correspond in correct and scientific thought. Definition is the means employed to give each idea its proper form and to fit it for being received into the mind as an exact, precise, and distinct representative of the thing defined. The aim of the logician in laying down the strict regulations which he does regarding definition, is to secure thoroughness of examination of all the essential qualities which distinguish one thing or phenomenon from others more or less apparently similar, and painstaking carefulness in the selection and use of those discriminating phrases by which the characteristic qualities of objects or operations are expressed representatively by or to the mind. The words of the definition require to be closely fitting, and when completely understood, the precise suggesters, to the inner power of the mind of a thinker, of that outer reality which has impressed the senses and excited the experience of the man. They must be such as bring experience and expression not only into a coexistent, but a consistent unity with the impression produced on the intellect. The proposition is the means by which the observed relations of things, and the results of the investigations made by the mind regarding these relations, and the relations between the inquiring mind and the things inquired about, are expressed. The *data* of experience are given to observation, gained by experiment or discovered by introspection, and their results are proposed to or by thought as the scientific statement of the mind's view of the relations of these data. It is obvious that in any such proposed statement the expression must neither contradict nor misrepresent experience, but lie precisely parallel, and be exactly equivalent to the realities which it is meant [or asserted] to represent; that is to say, the sensible observation of experience and the intellectual observation of consciousness must, though distinct, be known to be equally real, authoritative, and consistent; and then the proposition —*i.e.* the forth-placed statement—must be accepted as, so far as it goes, at once an incontestable fact of experience and a valid affirmation of the mind. Thus the clearly perceived and accurately defined perceptions of mental apprehension become correlated by judgment into propositions constituting knowledge, and are brought by the reason into higher and closer identifications through the syllogism as science or philosophy.

This *inleading* of experience within the sphere of the intellect, and bringing knowledge into and under the dominion of the mind, constitutes *induction*. Induction is of two sorts —(1) investigative; (2) ratiocinative.

Induction is the inleading of experience (1) into the intellect for the investigation of it as matter of fact, and (2) under the power of the intellect that it may be harmonized into theory and acquire the consistency of truth. Fact is the initial foundation of certainty. Fact is more than mere occurrence, that is, accident or incident, and is not (necessarily) trustworthy as a ground or sure and stable foundation

of knowledge. It is not even mere recurrence of phenomena —unless the occurrence and recurrence have had similar conditions issuing in similar results. Acts (or impacts made, in the flux of phenomena, upon the mind) are but, as it were, instants of actuality impressed on the mind. In the accumulated force of their repeated, recurrent, or continuous activity they acquire the coincident consistency of experience, and become facts. Facts have a perceptive, a receptive, and a preceptive development as mental phenomena. Impressions are, as logical elements of thought, nothing to us until we have perceived them—not with the distracted, unsteady, superficially-felt, merely sensational vagueness of a something that has happened, but with the accurate imprint of something requiring, demanding, and gaining attention. Then, when they present themselves clearly and strongly to the mind, they are received under the attestation of careful observation as elements of conscious experience, and thus as accepted facts we affirm that they are, seek to know with precision what they are, and to ascertain, if possible, why they are, and therefore be enabled to state what we really know or truly believe regarding them. Facts reveal themselves in their effects, and investigative induction is the logic of facts.

Investigative induction is the critical search for certainty of fact—fact rightly and rigidly discriminated alike from mere vague sensible impression and from the additions or perversions (conscious or unconscious) of inference or imagination—fact noted with scrupulous accuracy and registered with thorough integrity, free from admixture of assumption or hypothesis. Induction is not only the receiver, but the critic of that which the prehensile power of perception brings to it as fact. Those millions of phenomena which at once attract and distract thought, require to be known—known with at least practical sufficiency—and therefore must be either kept clear of, or have cleared away from them, all extraneous and superfluous associations or consociations, in order that we may have them brought into the view of the intellect clearly, distinctly, and with nothing else than their essential qualities concentrated into their unity. Then they can be arranged into classes and degrees; then the mind can assign them place and order, and try their fitness for filling the forms of the intelligence with real matter and not vain imagination. Thus induction enables us to acquire from our perceptions right conceptions, by gathering the scattered multitude of our individual and isolated experiences together under the one form implied by and crystallized into the term in which a conception is embodied in a word. Truly, then, induction is, as Aristotle says, "the progress from the particular to the universal," that is, from the special facts of experience to the general ground of our convictions as to the actuality of the facts affirmed by a consensus of experience, and which we can set forth in propositions. "It begins," as Bacon would have it, "from the senses and particulars, and ends in the highest generalities." By its aid we arrange objects or facts, according to well-considered points of agreement, into distinct classes. Then, by a diligent and careful comparison of these classes, by observing, attending to, and weighing mentally their agreements and disagreements, these objects and facts can be arranged still further into higher forms of classification. Sir William Hamilton, defining this form of induction to be an "*objective* process of investigating individual facts, as preparatory to illation," *i.e.* inferential reasoning, and regarding it as "an inventive process, a process of discovery," puts it aside "as beyond the sphere of a critical science." It would indeed be so were it really "an *objective* process," *i.e.* a process employed upon the outward object of investigation, instead of a mental process employed in guiding the intellect in its investigations of the representations given to it, through the senses, as the actual facts regarding any outward object. If the main uses of logic are to analyze the mental processes which are employed in reasoning, and to found upon this analysis a regular, true, consecutive, and instructive series of directions for the guidance of the mind when engaged in those investigations into the nature, constitution, and laws of things, which we call thought, and out of which we aim at constructing science and evolving philosophy, then that analysis of judgments, or of the propositions which are the results of our judgments, which investigative induction is intended to provide, must have a place, and that a very important one—as the warder of the castle of reasoning—within the sphere of logic as "a critical science." It is to seek theoretical symmetry, rather than practical utility, to affirm that it is no part of a logician's business to supply directions for the guidance of thinkers in the investigation of the accuracy of the constructive elements of syllogisms—propositions.

A more formidable objection would arise were we to accept the statement made by J. S. Mill, that "there is not properly an art of observing," as absolutely irrefragable; or if, while accepting his admission that "there may be rules for observing," we were also to adopt his view that these "are essentially rules of self-education, which is a different thing from logic." Logic is educative. It directs, pervades, and overrules all real education, all culture of the human faculties in man. It is expressly for its educative power that it claims a place among the sciences and gains culture as an art. "A right understanding of the mental process itself, of the conditions it depends on, and the steps of which it consists, is the only basis," as J. S. Mill states, "on which a system of rules, fitted for the direction of the process, can possibly be founded." Now, it is certain that the main condition on which the proper performance of the act of reasoning depends is that the premises furnished or adopted be accurately expressive of the facts of experience, and contain in them neither more nor less than the facts founded upon warrant. To determine that this condition has really been attended to and fulfilled, "we must endeavour to effect a separation of the facts from one another, not in our minds only, but also in nature. The mental analysis, however, must take place first. And every one knows," the words are those of J. S. Mill, "that in the mode of performing it one intellect differs immensely from another. It is the essence of the art of observing; for the observer is not he who merely sees the thing which is before his eyes, but he who sees what parts [qualities or properties] that thing is composed of [or is characterized by]. One person, from inattention or attending only in the wrong place [or at the wrong time], overlooks half of what he sees; another sets down much more than he sees, confounding it with what he imagines or with what he infers; another takes note of the *kind* of all the circumstances, but being inexpert in estimating their *degree*, leaves the quantity of each vague and uncertain; another sees, indeed, the whole, but makes such an awkward division of it into parts—throwing things into oneness which require to be separated, and separating others which might more conveniently be considered as one —that the result is much the same, sometimes even worse, than if no analysis had been attempted at all."

Nothing can be more erroneous, then, than the theory of the complete separation of observation and reasoning. "The operations of the mind," said G. H. Lewes, "are but a prolongation [*i.e.* a carrying into further recesses of thought] of external impressions, which again are reacted on by the former. Each act of reasoning requires a combination of these two processes. This is proved by the fact that the clearness of any conception depends upon the sufficiency and reiteration of external impressions."

Ordinary experience gives only casual and fitful knowledge. Observation sifts that unassorted flux of appearances, and looks for some (possible) simplification of its complicated multiplicity. The first point to be settled concerning experienced facts is their unquestionable certainty, that is, that these experiences have actually been impressed on, not imagined by us; and the second requirement upon the matter is to be perfectly assured that our experiences have been (and are capable of being) really and unmistakably represented in their own native characteristics without defect or surplus of effectiveness—that, in short, whatever may be its real nature, our mind is not by our consent and carelessness a deceptive mirror of things. These preliminaries assured, we can proceed to analyze and test the phenomena of experience. We can apply to these the threefold tests of Bacon—(1) presence, (2) absence, (3) variation. We place the perceptions which thought transforms into conceptions, and which constitute experience, under regulated observation, and by this means

endeavour to ascertain that, without heterogeneous element and in actual purity of presentation, it has been brought into and become known by the mind. Under this instrumental investigation we note how a particular experience affects us by its presence—what is the full impression it makes on us when it is thus consciously placed under the inspection of thought. Then, if it be possible, withdrawing that experience from impressing consciousness (or finding an occasion in which it is withdrawn and its pressure unfelt), we mark the difference of experience occasioned or produced by its absence. On its recurrence, either in ordinary course or by direct intervention of the interposing effort of our own will, we examine and compare the former experience with the present, paying special attention to any change in impression, condition, or circumstance, and if there be any change in the total sum of the experience corresponding in intensity, power, or satisfactoriness to the variations, if any, made palpable to the consciousness. In this way not only is non-observation provided against, but mal-observation is rendered almost impossible; and thus the common matter of fact collected by experience is elaborated by methodic treatment into the elements of scientific thought.

Each experience is an instance; each consciously and well-considered act of observative examination is an experiment by which each special experience scrutinized is compelled to give some account of itself to the warders, rendered circumspect by culture, at the several gateways of knowledge. Of course nature is richer than experience, and no single mind can take in all that nature presents in panoramic manifoldness. Hence it is difficult to prove a negative; for our non-perception of a definite special experience is no evidence of its non-existence—unless we could feel assured that the sensitiveness of our consciousness is so delicate and all-absorbent that it perceives and receives every possible impression, and that our individual mind has been so placed as to have had every possible phenomenon of nature brought within its ken in the moments of their keenest mutual co-efficiency. There are phenomena which pre-eminently impress us—phenomena even of the same kind. When such cases occur, or can be consciously arranged for, we should choose one of them, in preference to many of the latter, for examination, because the essential elements may be more easily and clearly ascertained in them than in others. A correct choice of such pregnant and prerogative instances by a judicious investigator may mark out the uniformities between it and many others so plainly that research may be materially quickened and classification made more certain. In the course of any comparative survey of the experiences of life or the phenomena of nature, we cannot fail to discover that there are qualities, properties, and characteristics in many of them lying superficially patent to observation, while many more are subtly latent, and require to be evoked before they yield their message to the mind. The cultivation in the intellect of a sensibility to these more latent impressions and the conditions of their being made manifestations is one of the results to be aimed at in investigative induction, the true purpose of which is the collection, examination, and manipulation of our mental experiences so as to discover and certify the propositions most suitable for syllogistic reasoning.

Induction thus employed and applied, when developed by syllogism and verified by ratiocinative induction, is the true means of accomplishing the desire of Bacon's spirit—the establishing in the human intellect of a true exemplar or transcript of the order of the real universe. The analytical and critical anatomy and dissection, as it were, of experience, by making us certain of its value, trustworthiness, and real place and signification, brings to us as results a series of convictions which we feel bound to accept and act upon as fixed bases of fact—firm resting-places on which we can rely, and which we set forth as possessions in those propositions which constitute science—*i.e.* a series of verbal statements which, when clearly understood in proper relation one to another, communicate to the mind real truth and form an intellectual mirroring of that nature by which we are surrounded in the words which represent it—a correct transcript of environing nature translated into the language of the intellect.

Science is the reasoned results of experience. Experience is the total of our perceptions. Actual perceptions, when guided and trained aright, yield us the facts of botany, natural history, &c. Perceptions classified and reasoned on with a disciplined mind result in giving us the sciences of geography, geology, and physiology. Perceptions intelligently arranged, carefully compared, reobserved in experiment, with the power of observation increased by artificial contrivances, furnish us with the knowledge which is comprehended under astronomy, chemistry, natural philosophy, &c. Thus as the mind is stirred to change the passive recipiency of merely routine sensation into that of active and disciplined observation, and passing onward from that to experimental contemplation and intentionally modified investigation, reaches the testing examinative skill from which verification results, experience is transmuted into truth—truth, however, which presents itself in propositions. Investigative induction shows us how to set the mind a-working among the unsought and spontaneously presented experiences which hit but scarcely move the passive mind, so as by forethought and arrangement, by the voluntary exercise of a determining will and intention, to learn whatever can be known regarding what presents itself to us. Hence logic directs us to keep all our senses alert and in good condition, maintaining their aptitudes and capacities in the highest possible activity, and having them always purposeful and ready for exercise; to select the objects of which an attentive survey is to be taken, with due regard to the information they can yield and the inquiry they may aid; to be prepared to place oneself in the most favourable position for close, steady, definite examination, and wherever it is possible, to vary the time, the position, and the circumstances in which we examine things. The due exercise of the art of observing often requires us to shut out from our minds every consideration except the one which has been chosen as that most requiring the absorbed attention of thought. The capacity of concentrating the entire capabilities of sense and intellect upon the most minute and seemingly insignificant object, and of fixing discriminating thought upon the slightest details or the smallest alteration of condition or power in the object engaging attention, is to be cultivated with such assiduity that the whole soul may be enwrapt in motionless meditation; and yet, in an instant, with complete self-mastery, on a fresh or unexpected manifestation of any hitherto latent specialty, the mind may change its purpose and relative limit of research. Cultured observativeness is alive, at once, to positive properties and to speculative probabilities. It keeps the whole being alive with thought and quickened to every possible change and chance. It learns to be all eye, ear, thought, and energy. It overlooks nothing of real importance, it looks at everything in its appropriate relation, and therefore it neglects no pertinent fact and misconceives no reality. The mind, thus self-centred and well-balanced, never loses its centre of gravity, and is never "hoist" among the perplexities of change. It is opposed to all the habits of mental slovenliness, and inclines and enables those who strive after its attainment to be in a high and highly philosophical sense

"Men of the world, who know the world like men."

Knowledge requires to be gained, verified, and expressed. The mental processes engaged in gaining knowledge are regulated by laws which vary with the varying nature of the matter investigated and the purpose of the investigation. Thinking is possible only when there is a thinking mind and a subject on which thought may be exercised; and thinking is therefore a compound process, affected not only by the laws which regulate the thinking mind, but also by the character of the objects on which man can think. The qualities in things which necessarily modify the manner of our thinking are (1) actual existence, as material facts and phenomena, capable of mental realization—*e.g.* hill, vale, stream, sky, seasons, plants, &c.; (2) possible existence, as implied in these facts and phenomena, capable of mental idealization—*e.g.* caloric, vitality, gravitation, electricity, polarization, &c. These two forms of thought make it possible to affirm or

deny, and determine the fact that all judgments, *i.e.* propositions, must be either affirmative or negative.

But thought discriminates as well as generalizes, and hence arises the distinction between particular or individual and general or universal, the determination regarding which elicits thought, as regards all thinkable things, in the two contrastive relations of (1) identity, *i.e.* consistent and continuous unity, indivisibility, and persistent self-sameness as an element of experience possible in thought; (2) diversity, *i.e.* distinctiveness both of quality and nature in essence and in specific being. There are given in our experience many *divers*—*i.e.* individually distinct identities—*e.g.* moor, mountains, scenes, feelings, &c., but there are qualities in each class of these which make them *diverse*, *i.e.* capable of being set apart from each other in thought as different one from another. This difference enables us to arrange them in classes. The former distinguishes things which are one and indivisible into individuals or particulars, the latter distinguishes things non-identical into classes according to their diverse properties. Every affirmative proposition is an assertion of identity, and every negative proposition is an assertion of non-identity, *i.e.* of diversity. Hence we deduce the three governing axioms of logical predication, *i.e.* of all possible logically valuable propositions, viz.:—

1. *Any two ideas must be capable of being either affirmed or denied of one another.* There is no medium course. The law of excluded middle rules supreme in all logical thinking. Any proposition in which this axiom is not observed is inconceivable. "Everything is either A" (a given thing) "or not A" (a thing which is not that given thing).

2. *Affirmative propositions*—to be secure against inconsistency, and to satisfy the principle of non-contradiction—*must have predicates which can be held in thought as identical with their subjects.* "A is A" is the inexorable primary form of logical affirmation.

3. *Negative propositions must have predicates which can be held in thought as diverse, non-identical with* (*i.e.* diverse from) *their subjects.* The peremptory formula of negation is "A is not A."

Contradictory terms—terms, that is, like "A" and "not A"—differ only in this single point, that the one has and the other has not the symbol of negation, either really or impliedly, prefixed to or otherwise included in it; *e.g.* "wise" and "not-wise" or "foolish" cannot in the same sense be affirmed of the same object or group of objects. Hence—

I. Every affirmative proposition is really an assertion that *A* (that is, the *subject*) and (let us now say) *B* (that is, the *predicate*) are, or stand as, signs for two different names of one and the same object or group of objects; *e.g.* Elizabeth was queen of England from 17th November, 1558, to 24th March, 1602–3; Every elephant is an animal; All poets are men.

II. Every negative proposition is an assertion that the subject *A* is a name standing for and representing one object or group of objects, and that the predicate *B* is or stands for the name of an object or group of objects different from that (or those) indicated by *A*; *e.g.* Observation is | no part of logic; Kings are | not subjects; Self-will is | not liberty.

CHEMISTRY.—CHAPTER X.

SELENIUM—TELLURIUM—SILICON—BORON—PHOSPHORUS—AMORPHOUS PHOSPHORUS—ARSENIC—ARSENIC COMPOUNDS.

SELENIUM (Se; atomic weight, 78·0; density, 78·0).—This very rare element, which closely resembles sulphur in its properties, occurs only in very small quantities, sometimes in association with sulphur in certain varieties of Swedish pyrites. It also occurs free in nature, and is found in combination with metals in certain rare minerals. It was discovered by Berzelius in 1817. Selenium melts at 217° C., and boils at a temperature below red heat, giving off a deep yellow vapour. In a finely divided state, and when seen by transmitted light, it has a red colour. It burns in air with a bright blue flame, which exhibits in the spectroscope a series of characteristic bands. The smell of burning selenium resembles that of rotten cabbages, and is due to the formation of an oxide, the composition and properties of which are at present unknown. Willoughby Smith discovered in 1875 that selenium possesses the abnormal property of changing its electric resistance under the influence of light. When carefully annealed at a temperature of about 220° C., it assumes a crystalline condition, in which condition it is very sensitive to light, the change of electric resistance varying directly as the square root of the illumination. Graham Bell has employed selenium in the construction of his photophone, an instrument for reproducing articulate sounds at a distance by the agency of light. Similar properties are possessed, though to a smaller degree, by tellurium, and carbon is also sensitive to light. Like sulphur, selenium is capable of existing in two allotropic forms, one of which is soluble in carbon disulphide, the other insoluble. The soluble form is precipitated when a solution of selenious acid is acted upon by a reducing agent—its specific gravity is 4·5; the insoluble modification results from the cooling of melted selenium—its specific gravity is 4·8. Selenium is a reddish-brown solid body, somewhat translucent, having an imperfect metallic lustre.

Selenium dioxide (SeO_2; atomic weight, 109·92).—This compound is formed when selenium is burnt in air or in pure oxygen. It can be obtained by oxidizing selenium in nitric acid or aqua regia. It is a white crystalline mass, dissolving in water, and thus forming selenious acid (H_2SeO_3). From this solution selenium is at once deposited on adding sulphurous acid, sulphuric acid being formed. The metallic selenites correspond closely with the sulphites.

TELLURIUM (Te; atomic weight, 128; density, 128).—This rare element possesses many of the characters of a metal in its physical properties, and bears likewise a strong analogy to sulphur and selenium in its chemical relations. It occurs combined with gold and other metals in Transylvania and Hungary. Its specific gravity is 6·24, and it exhibits a bright white metallic lustre. It fuses at about 500° C., and may be volatilized at a white heat in a current of hydrogen gas. When heated in air it burns with a bluish-green flame, forming white fumes of tellurium dioxide (TeO_2). This compound is also formed when tellurium is oxidized by nitric acid and the solution evaporated to dryness. With hydrogen tellurium forms a colourless gas, telluretted hydrogen (H_2Te), which is indistinguishable by its smell from sulphuretted hydrogen. Oxygen, sulphur, selenium, and tellurium form a natural group of elements, each uniting with two atoms of hydrogen to produce a series of substances possessing analogous properties (H_2O, H_2S, H_2Se, H_2Te). The last three exhibit the same kind of gradation of properties noticed with chlorine, bromine, and iodine.

SILICON (Si; atomic weight, 28).—Silicon does not occur in the free state, but always combined with oxygen to form silicon dioxide. Silicon also occurs combined with metals and oxygen, forming metallic silicates. To obtain silicon in the free state a compound of this substance with fluorine and potassium is heated with metallic potassium:

$$K_2SiF_6 + 4K = 6KF + Si.$$

A violent reaction takes place; and when the contents of the tube in which the decomposition has been effected are put into water, silicon is left undissolved in the form of a brown amorphous powder. Silicon can be obtained in two different modifications, amorphous and crystalline.

Silicon dioxide or *silica* (SiO_2; atomic weight, 59·92) is the only known oxide of silicon. See Earths, p. 456.

BORON (B; atomic weight, 11·0) is the basis of a substance which has been long and extensively used in the arts and in medicine, under the name of *borax*. It is found abundantly in Tibet and in South America, but in a state too impure to be used without refining. Borax has a sweetish taste, and is soluble in twelve parts of cold and two parts of boiling water. Its crystals are transparent, but effloresce and become opaque in a dry atmosphere, and they appear luminous by friction in the dark. It melts at a heat a little above that of boiling water, and gives out its water of crystallization, after which it forms a spongy mass, well known as calcined borax. When further heated to ignition, it passes into a glassy-looking substance, known as glacial borax.

If a quantity of glacial borax, finely powdered, be intimately mixed with a tenth of its weight of powdered charcoal, and the whole be heated intensely in an iron tube, closed at one end, a black powder is obtained. This being washed several times with hot water, then with hydrochloric acid (spirit of salt), and finally with water, assumes a blackish-olive colour; it contains some charcoal and another ingredient, which is *boron*. The blackness is chiefly derived from the charcoal; the boron in a state of purity is an opaque brownish-olive powder. Boron burns when strongly heated in oxygen or in chlorine, forming the oxide or chloride. Nitric acid, alkalies in the fused state, chlorine, and other agents readily attack it. Burned in pure oxygen, the compound formed during the combustion contains 31 per cent. of boron and 69 of oxygen. It possesses the properties of an acid, and is therefore called *boracic acid;* and this, when combined with soda, forms the borax of commerce.

Boracic or *boric acid* (H_3BO_3; atomic weight, 61·88).—Boracic acid is obtained in unlimited quantity from the water of the hot volcanic lagoons of Tuscany; the water requires simply to be evaporated until the acid solution has been sufficiently concentrated to afford crystals. Native boracic acid is also found among the volcanic products of the Lipari Islands. It exists also in the waters of some hot springs, as in those of Sasso, in the Florentine territory, and in some minerals, as datolite and boracite.

Dry borax, at a high temperature, has the remarkable property of melting and vitrifying the metallic oxides into glasses of different colours. On this account it is a most useful reagent for the blowpipe. With oxide of chrome it forms an emerald green glass, and with oxide of cobalt an intensely blue glass. Oxide of copper tinges it pale blue; oxides of iron, bottle green; oxide of tin, opal; oxide of manganese, violet; oxide of nickel, pale yellowish-green. With the oxides of silver and zinc, and with several of the earths, it forms white enamels. Borax, in consequence of this property of vitrifying the metallic oxides, is used to clean the surfaces of metals, in processes of soldering with hard solder and of welding cast-steel. It is also valuable in the fusion of metals to protect their surface from oxidation.

PHOSPHORUS (P; atomic weight, 30·96; vapour density, 61·92).—Phosphorus does not occur free in nature. It is contained in the form of phosphoric acid in the unstratified rocks; as these disintegrate and crumble down to form fertile soil the phosphates pass into the organism of plants, and ultimately into the bodies of the animals to which the plants serve for food. It is therefore found in large quantities in the bodies and bones of animals and in the seeds of plants, and also as the minerals phosphorite and apatite. When bones are burned, a white solid mass is left; this is called calcium phosphate, or phosphate of lime. Phosphorus was accidentally discovered in 1669 by Brand of Hamburg, who prepared it from urine. Scheele, in 1771, pointed out the existence of phosphorus in the bones, and carefully examined its properties. Phosphorus is prepared from powdered bone ash, by mixing it with two-thirds of its weight of sulphuric acid, and 15 to 20 parts of water. The acid decomposes the bone ash, forming calcium sulphate or gypsum, which separates as a white insoluble powder; while the greater part of the phosphorus in the bones comes into solution in combination with calcium, oxygen, and hydrogen, forming calcium hydrogen phosphate, a salt known as superphosphate of lime, and largely employed in the manufacture of artificial manures. The liquid is drawn off clear, and evaporated to a sirupy consistence, and then mixed with charcoal powder, dried, and heated to redness in an earthenware retort, the neck of which dips under water. The soluble phosphate is by this converted into calcium metaphosphate, which is decomposed on heating. The phosphorus is liberated together with carbon monoxide and distils over, collecting under the water in yellow drops, the other third remaining behind in the retort as calcium triphosphate. After purification by pressing when melted under hot water through leather, it is cast into sticks or wedges, and kept under cold water. Phosphorus is an exceedingly inflammable and oxidizable substance, and requires great care in its preparation. It is manufactured on a very large scale by Albright & Wilson at Oldbury, near Birmingham. It is largely employed in the manufacture of lucifer matches, and in the preparation of phosphide of calcium for the Holmes life-rescue signals and torpedo-finders. Phosphorus is a slightly yellow semi-transparent solid, greatly resembling wax in appearance and consistency. At a low temperature it becomes brittle. Its specific gravity is 1·83, melting point 44·3° C., when it forms a transparent liquid; it boils at 290° C., forming a colourless gas. Phosphorus in the air gives off white fumes, emitting in the dark a pale phosphorescent light. It is then undergoing slow combustion in combination with the oxygen in the air, the white fumes consisting of *phosphorus trioxide* (P_2O_3). Phosphorus is a very dangerous substance to manipulate, as at a temperature very little above its melting point it takes fire in the air, entering into active combustion and forming *phosphorus pentoxide* (P_2O_5). The ignition of phosphorus will also take place by the slightest friction, or by a blow, and the heat of the hand is often sufficient to set it in flames; hence the greatest care is necessary in its manipulation. It should never be touched by the hand, and should always be cut and divided under water. Phosphorus is insoluble in water, alcohol, and ether, but is slightly soluble in oils, and readily soluble in carbon disulphide. There are several allotropic modifications of phosphorus, the most important of which is the *red* or *amorphous phosphorus*. When yellow phosphorus is exposed to a temperature of about 240° C. for several hours in an atmosphere of hydrogen or carbon dioxide incapable of acting chemically on it, the phosphorus undergoes a remarkable change, being wholly converted into a red opaque substance, altogether insoluble in carbon disulphide. The weight of the red substance produced is precisely that of the yellow phosphorus employed. This substance is termed *red* or *amorphous phosphorus*, and is greatly different in its properties from yellow phosphorus, especially in its inflammability, as it does not ignite in air until heated above 260° C., when it becomes reconverted into yellow phosphorus. The specific gravity of amorphous phosphorus is 2·11.

Phosphorus forms two compounds with oxygen—phosphorus trioxide (P_2O_3) and phosphorus pentoxide (P_2O_5). It also forms three compounds with hydrogen, one a gas, PH_3; the second a liquid, P_2H_4; and the third a solid, P_4H^2.

Phosphuretted hydrogen or *phosphine* (PH_3; atomic weight, 33·96; density, 16·98).—This gas may be obtained in a pure state by the action of caustic potash on phosphorus:

$$3KOH+P_4+3H_2O=3KPH_2O_2+PH_3.$$

It is a colourless gas, with an odour resembling the worst stage of putrid fish. Each bubble of the gas takes fire spontaneously on contact with the air, forming regular rings of phosphorus pentoxide, which expand regularly as they rise. This self-inflammability of the gas depends upon the presence of small quantities of the liquid hydride (P_2H_4).

Phosphorus forms two compounds with chlorine—*phosphorus trichloride* (PCl_3) and *phosphorus pentachloride* (PCl_5).

ARSENIC (As; atomic weight, 74·9; density of vapour, 149·8).—It should be noticed here that the volume occupied by an atom of gaseous arsenic and phosphorus is only one half of that occupied by the other elements generally; hence the atomic volume of arsenic and phosphorus is half that of the preceding elements taken as one. The molecules of arsenic and phosphorus consist, therefore, of four atoms.

Arsenic very nearly resembles phosphorus in its chemical properties, and in those of its compounds, though it bears a greater analogy to the metals in the matter of its specific gravity, lustre, &c., and may be considered the connecting link between the two divisions of the elements, antimony and bismuth being closely in alliance with it on the one side and phosphorus and nitrogen on the other. Arsenic is sometimes found native in the free state, but more frequently combined with iron, nickel, cobalt, and sulphur. It is likewise found in small quantities in many mineral springs. Arsenic is separated from the metallic ores in which it occurs by the process of roasting or exposing the ore to a

current of heated air in a reverberatory furnace. The arsenic combines with the atmospheric oxygen, forming arsenic trioxide (As_2O_3), which in the state of vapour is carried from the furnace into condensing chambers, in which the trioxide or white arsenic is deposited. Metallic arsenic is prepared from this oxide by mixing it with charcoal and sodium carbonate, and heating in a closed crucible, the upper portion of which is kept cool, in which the arsenic condenses as a solid, with a brilliant grayish lustre, and a specific gravity of 5·7. When heated to dull redness it volatilizes as a colourless vapour, possessing a strong garlic-like odour. When heated in the air arsenic burns with a bluish flame, forming arsenic trioxide (As_2O_3), and when thrown into chlorine it instantly ignites, forming arsenic trichloride ($AsCl_3$). There are two compounds of arsenic and oxygen known—arsenic trioxide (As_2O_3) and arsenic pentoxide (As_2O_5).

Arsenic trioxide (As_2O_3; atomic weight, 197·8; density of vapour, 197·8) is formed when arsenic is burned in air or hydrogen. It exists in two distinct forms—the crystalline and the vitreous. In the first it occurs crystallized in brilliant octahedrons; in the second as a semi-transparent glass-like solid, devoid of crystalline structure. Arsenic trioxide is feebly soluble in water. It dissolves more readily in hydrochloric acid, and is soluble also in solutions of the alkalies, arsenites being formed under the general class M_3AsO_3. The alkaline arsenites are soluble in water; those of the metals of the alkaline earths and heavy metals are insoluble in water. Sodium arsenic is largely used in calico printing. Scheele's green and emerald green are compounds containing arsenic trioxide and copper, both of which are made in large quantities as colouring pigments. Wall papers and paints coloured with these preparations are highly injurious. All the soluble arsenites are deadly poisons; the best antidote for them is freshly prepared ferric hydrate or magnesia, which forms insoluble arsenites, and therefore arrest the progress of the poison from entering into the system.

Arsenic pentoxide (As_2O_5; atomic weight, 229·6).—This oxide, *arsenic acid*, is obtained by acting on the trioxide with nitric acid, evaporating to dryness, and heating to a temperature of 270° C. It forms a non-crystalline white powder, which, when dissolved in water, yields crystals of arsenic acid (H_3AsO_4). Arsenic acid is a poison, but less deadly than arsenious acid.

Arseniuretted hydrogen (AsH_3; atomic weight, 77·9; density, 38·9) corresponds to phosphuretted hydrogen and to ammonia; it is formed by decomposing an alloy of arsenic and zinc with sulphuric acid. It is a colourless gas, with a fetid odour of garlic, and is a most deadly poison, the discoverer, Gehlen, having been killed by simply inhaling a single bubble of the pure gas. Arseniuretted hydrogen burns with a bluish flame; below a red heat it is decomposed into arsenic and hydrogen.

Arsenic unites with chlorine, bromine, and iodine, forming *arsenic trichloride*, *tribromide*, and *tri-iodide*. The trichloride is a colourless volatile liquid, boiling at 134° C., which decomposes in contact with water, forming arsenious and hydrochloric acids.

The *three sulphides of arsenic* are arsenic disulphide (As_2S_2), which is found naturally as realgar; trisulphide (As_2S_3), also occurring in nature as orpiment; and pentasulphide (As_2S_5). Orpiment may be obtained by passing a stream of sulphuretted hydrogen gas through the acid solution of the corresponding oxide, when it is precipitated as a yellow powder.

The general chemical analogy between nitrogen, phosphorus, and arsenic is well seen on examination of their corresponding compounds. Thus the oxides, hydrides, and chlorides have an analogus composition.

N_2O_3	...	N_2O_5	...	NH_3	...	NCl_3
P_2O_3	...	P_2O_5	...	PH_3	...	PCl_3
As_2O_3	...	As_2O_5	...	AsH_3	...	$AsCl_3$

These three elements are all *trivalent*—that is, one atom of each of these bodies is equivalent to, and capable of replacing, three atoms of hydrogen.

SHORTHAND.—CHAPTER VI.

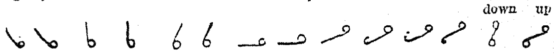
THE SIGNS FOR FINAL S AND ITS COMPOUNDS — HALF-SIZED CONSONANTS—EXERCISES.

FINAL *S*.

Though, upon page 560, we occupied considerable space in communicating details as to the numerous forms in which the sibilant appears, we were not able to complete all the instructions necessary for the management of the *s* formations in their various compounds. So far as initial and medial groups are concerned, what has been taught may suffice in a series of elementary papers such as these. But *s*—as a factor in English spelling, owing to its use in the plural of nouns, in the third person singular of verbs, &c.—takes also a large number of final combinations. In dealing with these, we require to remember its use both as a sharp and a flat, and to take care that we distinguish rightly those words in which this difference distinctly appears. We must now ask the student's careful attention to what requires to be said in regard to final *s*, and to the exercises subjoined, which are intended to exemplify and afford practice in the use of such special terminal phonographic forms.

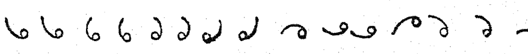
S is affixed to straight consonants on the same side (the right) as in the case of an initial *s*, thus:—

down up



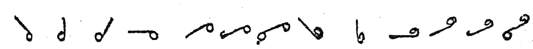
ps, bs, ts, ds, chs, js, ks, gs, rs, ws, whs, ys, hs, hs.

After a curve, the circle should follow the sweep of the curve.



fs, vs, ths, ths, ss, zs, shs, zhs, ms, ns, ngs, ls, rs, rchs, mps.

As circle *s* may be *prefixed* to hooks *r* and *l*, so it may be *affixed* to hooks *n* and *f* or *v*, thus:—



pns, tns, chns, kns, rns, wns, hns, pfs, tfs, kfs, rfs, wfs, hfs,

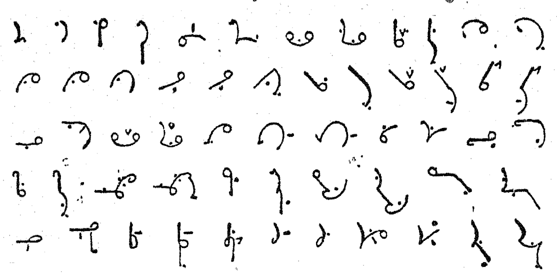
as in *pains*, *tones*, *chains*, *coins*, *once*, *puffs*, *doves*, *coughs*, *waves*.

S is added to a final *n* or *tion* hook after a curve thus, *feigns*, *lines*, *means*, *urchins*, *nuns*, *queens*, *woollens*, *cautions*, *visions*, *orations*, *motions*.

The circle is made of double size to represent *ses*, *sez*, as seen in the words *cases*, *classes*; and when formed on the left side of a straight consonant it adds *nses*, as *chance*, *chances*; *expense*, *expenses*; *dunce*, *dunces*.

The circle *s* may be thickened to express the sound of *z*, as *peace*, *peas*; *pence*, *pens*; and the hook *f* may be thickened to represent *v*, as *brief*, *brave*.

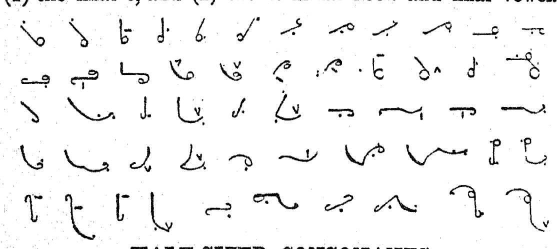
The student should copy out very carefully the following exercises, and should bear in mind—1st, that circle *s* at the end of a word is read with the pronunciation of the word *last*, that is, after the vowel; 2nd, that when a vowel precedes *s*, or a vowel follows *s*, the stroke *s* must be used, as *ask*, *glassy*; and 3rd, that when a word begins with *z*, the stroke is used, as *zeal*, *zany*.



FINAL *ST* LOOP, &c.

A final loop represents the *st* combination so common in superlatives, verbs, &c. It is formed on the inside of curves and on the *f* hook side of a straight consonant. It represents *nst* on the *n* hook side of a straight consonant; thus:— *past,* *fast,* *cast,* *canst,* *against,* *rinsed.* The *st* loop is most generally used initially and finally; but it may also be employed medially, as in *justify,* *testify.* Final *s* may also be added to the *st* loop, as *feasts,* *posts,* *Christ's.* A wider loop, two-thirds of the length of the consonant, represents *str,* thus— *pastor,* *muster,* *minister.* This loop may also be combined with the final *pn* series of straight letters, as *punster,* *spinster,* *spinsters.* The student must bear in mind that the same rule is applicable to the *st* loop and to the final hooks *f, v, n,* as to the circle *s* or *z,* viz., that a vowel cannot be read before or after it, as *lust,* *lusty,* *crust,* *crusty.*

Circle *s*, at the end of a word, is read last, that is, after the vowel. The following exercises are given to illustrate (1) the final *s*, and (2) the terminal hook and final vowel.



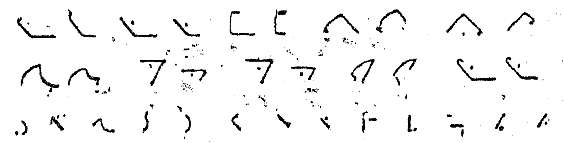
HALF-SIZED CONSONANTS.

The special point to the treatment of which we have now come is very important. At first sight it may perhaps seem a rather difficult adaptation of the principle of the phonographic art, namely, that of expressing *t* or *d* by half-sized consonants.

If a thin consonant is made one half its usual size, it generally indicates an additional *t*, and similarly a thick letter when halved expresses *d*; thus, *poke,* *poked;* *wrap,* *wrapped (rapt);* *fetch,* *fetched;* *rob,* *robbed;* *gray,* *grade;* *beggared.*

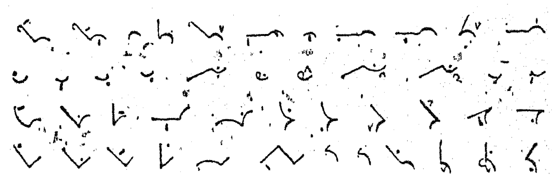
In some cases a thin stroke may be halved to denote the addition of *d*, and a thick one to show the addition of *t*; as, *rapid,* *habit,* *beautiful.*

A vowel, or vowel sound, placed *before* a half-sized consonant, is read before *both* letters; as, *east,* *oft,* *act;* but a vowel *after* a half-sized consonant is read before the *added* letter, as *pay,* *pate,* *die,* *died,* *plagued.* The following exercise will illustrate the first part of this halving principle, as well as the use of the vowels:—



The letters *m, n, l,* and the downward *r* are made half-length to add *t*, and these short characters are thickened to add *d*. *Ld* is written downwards. Thus it will be seen that this does not admit of *mp* *ng* *lr* and *rch* being halved, but, as we shall explain further on, they may be halved when hooked finally, as in *impend,* *urgent.*

We would draw the learner's particular attention to the following rules: (1) When the circle *s* follows a half-size consonant it must be read after the *t* or *d* added to the primary letter, thus would not be *pst*, but *pts;* (2) no vowel can be placed after the *t* or *d* which is added by halving; thus *practice* must be written not ; *faulty* must be written not . The following exercise will help the student to understand the simple form of the principle of halving as applied to curved characters.



A full-sized and a half-sized consonant should not be joined unless they form an angle at the point of union, or the difference is shown by a distinction in thickness, and in cases where the half-length runs in the same direction, as in the words *cooked, fact, dated,* which should be written in full thus , otherwise it would be difficult to distinguish whether it were or were not meant for a single letter, full-sized and half-letter, or two full-sized letters.

One of the most important uses of the halving principle is to express the past tense of the regular verb, as *voted,* *cheated,* *fasted;* but in many cases the past tense is represented by the sound *st*, and then the *st* loop is used, as *announced,* *produced,* *reduced.* Words that end with the sound of *z*, as *caused, gazed,* should be written thus, , when only one stroke precedes, and by the *st* loop when two or more, as *refused,* *indisposed.*

In our next lesson we shall further illustrate the application of this halving principle to hooked letters, and supply and give the list of grammalogues or letter words. This will enable the student to read the books, in the learner's style, published by Mr. Pitman, and the simple exercises in the *Phonetic Journal*, published weekly, price one penny.

We need hardly remind the student of the necessity of carefully copying and recopying the exercises given in this chapter, endeavouring, while doing so, to form the characters neatly, and to make the distinction between full and half-sized consonants marked and clear. The writing out of the words which the characters represent immediately below the shorthand signs of them is indispensable to a ready knowledge of phonographic writing. Accurate transcription of forms must be accompanied by fluent translation into sounds.

In selecting one out of two or more possible forms for any word, the student must recollect that great ease in writing, and consequently the saving of time, is not secured by using hooked and grouped, and especially half-sized letters, on all possible occasions; but he must learn to make a judicious selection, and employ those which are most readily made in any given case, and not adopt those forms that merely take up the least room.

MUSIC.—CHAPTER VI.

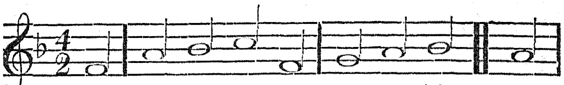
TRANSITIONS, THEIR USES AND LAWS—EXPLANATORY EXAMPLES—EXERCISES.

In Chapter IV., page 464, attention was called to the fact that, notwithstanding the great variety and striking originality of the productions of different composers, the musical scale is limited to seven tones, with a constant repetition of the same at a higher or lower pitch. There is, however, only a seeming paucity of musical materials. When we come to think of the numberless ways in which these seven tones can be arranged, of the nature and power of accent and rhythm to give meaning and interest to music, and above all, when we become aware that even in a short tune the whole scale can be, and generally is, lowered or heightened, we begin to perceive that the resources of the musician, so far from being limited in their nature, are almost infinite in number and unlimited in their possibilities. So it has come to pass that when Bach and Handel had worked in this musical mine till its wealth seemed well-nigh exhausted, Mozart and Haydn, Cherubini and Beethoven, Mendelssohn, Schubert, and Wagner have each in their turn arisen and enriched the world with masterpieces upon which their individuality is as strongly stamped as if not a single note had been previously written.

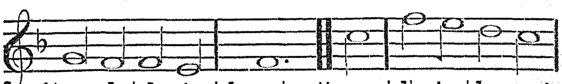
The distances or intervals by which the different tones of the scale are separated one from another were given at page 175. In this arrangement, as already explained, each tone produces a particular effect on the mind (p. 464), as bright, restful, sorrowful, expectant, or conclusive. It will be readily understood that this natural arrangement must ever hold good. If a tone foreign to the key or scale in which we have been singing or playing is introduced, immediately these effects are transferred from one tone to another—the restful tone becomes expectant, the strong supporting Doh becomes weak and in itself unsatisfactory; in other words, we have changed the key, and the note that was originally Soh or Fah, or it may be Ray or Lah, has become Doh. The mental effect of the other scale-tones are altered accordingly, while they minister, as it were, to the new ruler as they did to the old. This change is sometimes called a *transition*, sometimes a *modulation*, but, for reasons which will appear further on, we prefer using the former term.

The most natural and easy transition, and the one most frequent in its occurrence, is that in which Soh becomes Doh. To make this transition we have simply to introduce a new tone, half a tone below Soh, instead of Fah, which, as we know, is distant from it by a whole tone. Let the student sing over the well-known psalm tune "French," observing carefully the third section of it, and most particularly the penultimate note of that section.

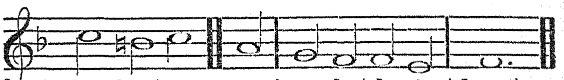
Key F. TUNE, "FRENCH."



{:d |m :f |s :d |r :m |f ||m }



{|r :d |d :t, |d :— |— ||s |d' :t |l :s }



{|s :fe |s ||m |r :d |d :t, |d :— |— ||

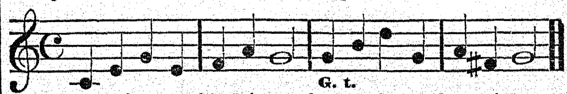
In the key of F, as we know (p. 563), the ordinary notation requires a flat on the third staff-line to bring the semitones into proper relation for that key. At the point to which attention is called, however, this flat is removed by a natural. The note which follows this natural is in consequence raised half a tone, and we are no longer in the key of F, but in what is called the natural key of C, for the flat has been taken away.

In sol-fa, when the transition is of short duration, this changed or raised note is called Fe; but when the change of key is to continue for any considerable time, the real notes of the change are given. It will be seen from the annexed modulator that when this transition is made the Doh' of the original key is equal to Fah of the new, Te = Me, Lah = Ray, Soh = Doh, and Fe is really the new Te that has been introduced—thus forming the distinguishing tone between the new key and the one we have left, the old Fah of which has disappeared. If the student will sing over slowly this third section of the tune, listening carefully for the mental effects, and watching keenly the natural tendency of the tones as they follow each other (which has been called the form of the melody), he will find that, with the exception of the first note, the whole section would be more correctly written thus—

s	d'	f
	t	m
f—*ta*		
m	l	r
r	s	d
	fe—t,	
d	f	
t,	m	l,
l,	r	s,
s,	d	f,

|d' $\overset{Key\ C.}{=}$ f' :m' |r' :d' |d' :t |d' ||

The foregoing appears in what Mr. Curwen calls the "better method" of writing and studying transition; the first way, that in which Fe was the only strange note, may be called the imperfect way of writing, wherein the change that has really taken place is more or less concealed. The change of key in which Soh becomes Doh is called a "first sharp transition," because it is the key most nearly related to the principal or original one on the sharp, or right hand, side of the modulator, and only one note of the first key (Fah) has been displaced, and that by one-half a tone higher or *sharper*. A few experiments in this transition will prove to the student its simplicity and beauty, and will give him some idea of its importance as a factor in giving vital expression to musical thought and feeling.

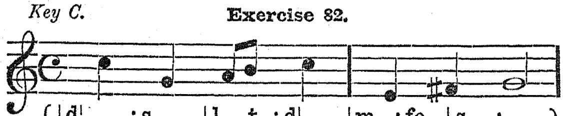
Key C. **Exercise 81.**

G. t.

{|d :m |s :m |f :l |s :— |ˢd:m |s :d |r :t, |d :— ||
or |s :t |r' :s |l :fe |s :— ||

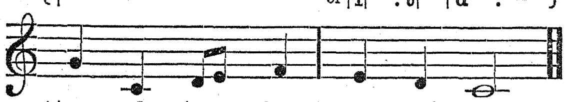
In the next three exercises the transition is made at the

close of the first section, and they all return to the principal key by the introduction of the old Fah.

Key C. **Exercise 82.**

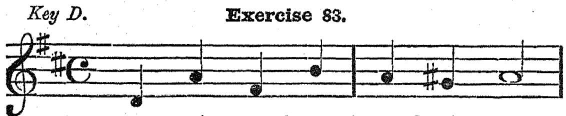


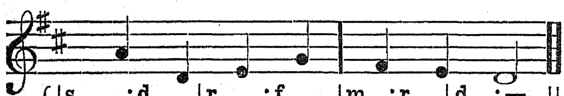
d' :s |l .t :d' |m :fe |s :—
or |l, :t, |d :—



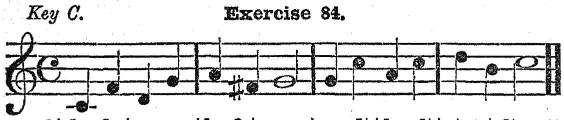
s :d |r .m:f |m :r |d :— ||

Key D. **Exercise 83.**



d :s |m :l |s :fe |s :—
or |d :t, |d :—

s :d |r :f |m :r |d :— ||

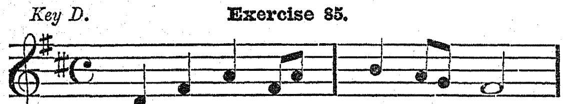
Key C. **Exercise 84.**



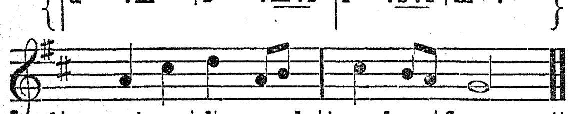
d :f |r :s |l :fe|s :—|s :d'|l :d'|r':t|d':—||
or :d |r :t,|d:—|

We may also make a transition to the other or flat side of the modulator by introducing a new Fah instead of the original Te. Let the student try to sing the following:—

Key D. **Exercise 85.**



d :m |s :m .s |l :s .f |m :—

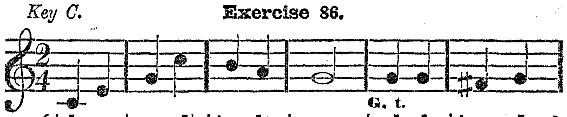


s :t |d' :s .l |t :l .s |f :— ||

The second section of Exercise 85 will be found much more interesting and easy to sing if, instead of C sharp (Te) in the last bar or measure, we use C natural (called in sol-fa Ta); in other words, if we make a transition to the first flat key, and transform our old Fah into Doh (see modulator, p. 656). This is called "a first flat key transition," because we have thrown out our original Te and put in a new note half a tone lower or flatter, which becomes Fah to the key we have introduced.

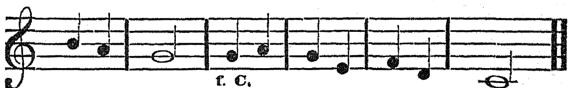
Transition to the first sharp or first flat key is nearly always followed by a return to the original tonic, because it is the key of first impression, and has established itself in the mind as the principal key. There are very few compositions that do not begin and end in the same key. Let it be carefully observed that the return to the original from the first sharp key is the same thing in its nature as making a transition to the first flat key, *i.e.* we throw out a Te and put in a Fah; and that, coming from the first flat key back to the original or principal key, is like making a first sharp transition, *i.e.* we throw out a Fah (Ta) and put in a Te (Fe). The following exercises show the transition sharp or flat, and the return. In sol-fa when the transition, as here, is given in the "better method," the distinguishing tone between the new key and the old is placed beside the key named. In the case of a sharp transition, as when Soh becomes Doh, the new Te is placed after it; in that of a flat transition, as when Fah becomes Doh, the new tone (Fah) is placed before the key-name. This is done to call attention to the tone that has been thrown out, and to that which may be expected in its stead.

Key C. **Exercise 86.**



G. t.

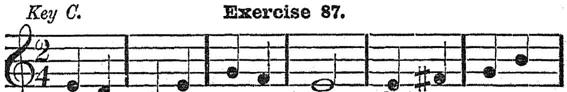
d :m |s :d' |t :l |s :— |^{s}d:d |t, :d
or | s:s |fe :s



f. C.

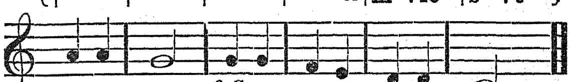
m:r |d :— |^{d}s:l |s :m |f :r |d :— ||
t :l |s :—

Key C. **Exercise 87.**



G. t.

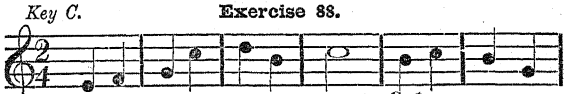
m:r |d :m |s :f |m :— |^{m}l, :t, |d :m
or |m :fe |s :t



f. C.

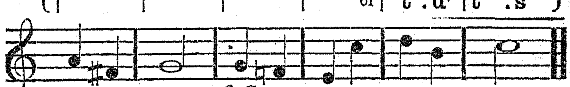
r :r |d :— |^{d}s :s |f :m |r :r |d :— ||
l :l |s :—

Key C. **Exercise 88.**



G. t.

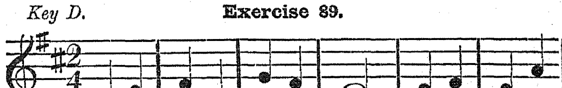
m :f |s :d' |r' :t |d' :— |^{t}m:f |m :d
or | t :d' |t :s



f. C.

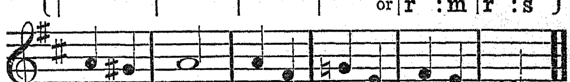
r :t, |d :— |^{d}s:f |m :d' |r' :t |d' :— ||
l :fe |s :—

Key D. **Exercise 89.**



A. t.

d :r |m :d |f :m |r :— |^{r}s,:l, |s, :d
or |r :m |r :s



f. D.

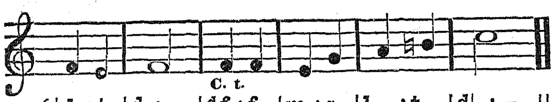
d :t, |d :— |^{d}s:m |f :r |m :r |d :— ||
s :fe |s :—

It should be carefully observed that just as G is first sharp key to C, so A stands in the same relation to D; that is to say, in going from the one to the other we throw out Fah and put in a new Te—in fact, we require an additional sharp. The next two exercises are examples of extended transition to the first flat key.

Key C. **Exercise 90.**

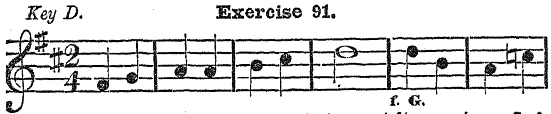
f. F.

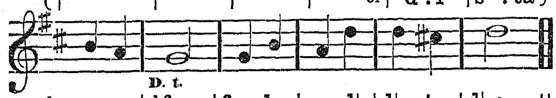
s :f |m :s |d' :t |l :— |^{l}m:f |m :r
or | l :ta |l :s



C. t.
{ |d :t, |d :— |^{d}f :f |m :s |l :t |d' :— ||
{ |f :m |f :— |

Key D. **Exercise 91.**



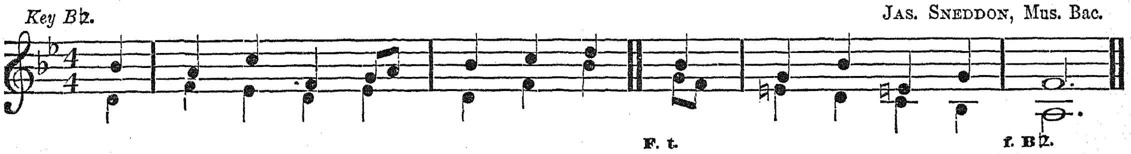
f. G.
{ |m :f |s :s |l :t |d' :— |$^{d'}$s :m |r :f }
{ | or| d':l |s :ta }

D. t.
{ m :r |^{d}f :— |f :l |s :d' |d' :t |d' :— ||
{ l :s |f :— |

In this last exercise, to get from D to G, we had to take off a sharp. This, it will be understood, has exactly the same effect as putting on a flat, *i.e.* it depresses the note before which it is placed by half a tone, giving a new Fah in place of the original Te.

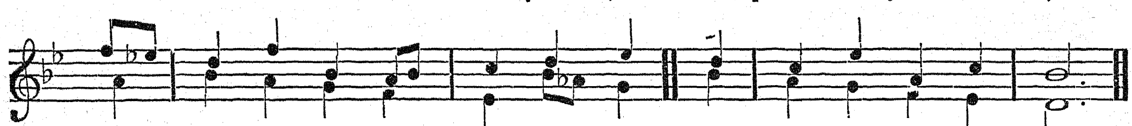
In psalm tunes, and tunes of similar length, transition to the first sharp key most frequently takes place at the end of the second line or section, and not seldom affects only the last three or four pulses of it. This is called a "cadence transition," because it has to do entirely with the close or cadence, and in sol-fa it is written in the "imperfect" manner. Occasionally, as at the end of the third section in Exercise 92, we have a cadence transition to the first flat key; but this transition most frequently occurs in the middle of a section, and is of so short a duration that it is called a "passing transition." In extended productions the composer frequently makes lengthened excursions into both first sharp and first flat keys, very often indeed allowing his music to wander into keys much more remote. When a change of key continues for a whole section, or when it goes beyond a section, we have what is called an "extended transition," which, in sol-fa, should always be written in the "better method."

Exercise 92.—TUNE, "KELSO." (*Arranged in two parts.*)

Key B♭. JAS. SNEDDON, Mus. Bac.

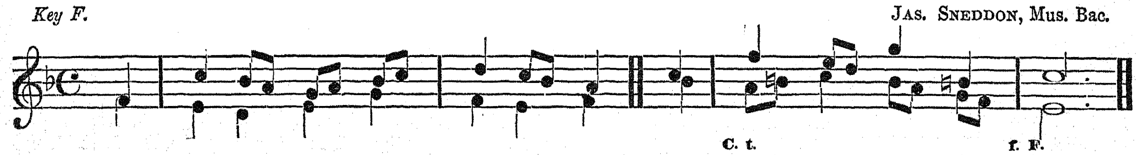
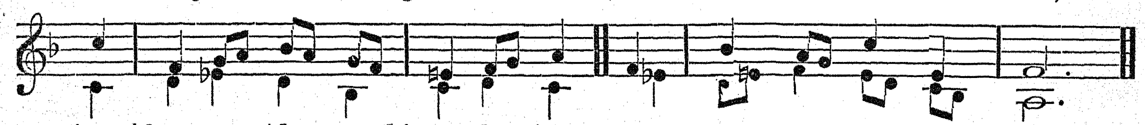


F. t. f. B♭.
{:d |t, :r |s, :l, .t, |d :r |m ||^{d}f |r :f |t, :r |^{d}s, :— |— ||
{:m, |s, :f, |m, :f, |m, :s, |d ||^{l,}r .d |t, :l, |s, :f, |^{m,}t, :— |— ||
I wait - ed for the Lord my God, And pa - tient - ly did bear;



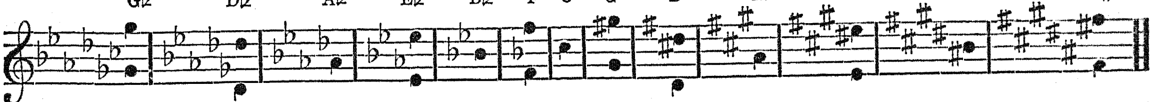
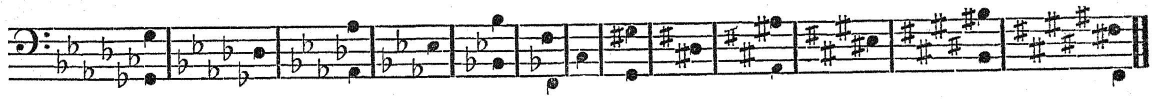
{:s .f |m :s |d :t, .d |r :m |f ||m |r :f |t, :r |d :— |— ||
{:t, |d :t, |l, :s, |f, :d .ta |l, ||d |t, :l, |s, :f, |m, :— |— ||
At length to me he did in - cline, My voice and cry to hear.

Exercise 93.—TUNE, "PENICUIK." (*Arranged in two parts.*)

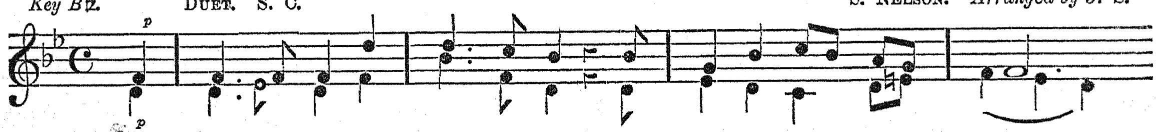
Key F. JAS. SNEDDON, Mus. Bac.

C. t. f. F.
{:d |s :f .m |r .m :f .s |l :s .f |m ||s |^{d}f' :m' .r' |s' :t |^{d}s :— |— ||
{:d |t, :l, |t, :r |d :t, |d ||f |m l .t :d' |t .l :s .f |^{m}t, :— |— ||
O sing a new song to the Lord, For won - ders he hath done;

{:s |d :r .m |f .m :r .d |t, :d .r |m ||d |f :m .r |s :t, |d :— |— ||
{:s, |l, :ta, |l, :f, |s, :l, |s, ||ta, |l, .t, :d |t, .l, :s, .f, |m, :— |— ||
His right hand and his ho - ly arm Him vic - to - ry hath won.

The attentive student will have noticed that, besides affording variety, transition to the first sharp key has a brightening, enlivening effect on the music. The second section in Exercise 93 is a good illustration of this. Transition to the first flat key is expressive of seriousness and depression. These two keys are so closely related to the original, and the change to one or other of them is made so frequently, that it will be advisable to make careful study of the three-key modulator given p. 656. By the student of the ordinary notation it should ever be remembered that sharps and flats are merely signs used to show where the semitones occur. The sol-fa notation clearly proves that they are required in instrumental much more than in vocal music. All scales or keys have the same arrangement of semitones—pitch is the only difference between one and another. In writing music it has been found convenient to take C as the standard scale or starting-point for keys. In the following table, by J. S. Curwen, this natural key, as it is called—having neither sharps nor flats—is placed in the centre, and the relation of each of the other keys to this is clearly shown in both

notations. It will be seen that the sharp keys from C go to the right, the flat keys to the left, and that the signature and position of Doh, the key tone, is given in the treble clef above and in the bass clef below.

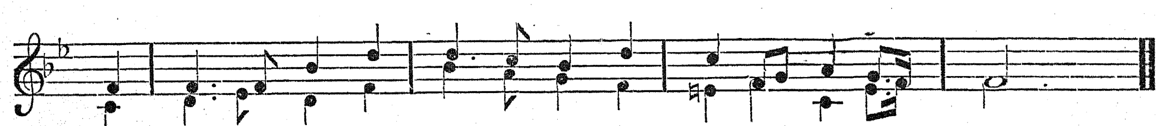
THE EXTENDED MODULATOR.

	G♭	D♭	A♭	E♭	B♭	F	C	G	D	A	E	B	F♯	
C'		t	m	l	r	s	d'	f						C'
B	f						t	m	l	r	s	d	f	B
	m	l	r	s	d	f						t_1	m	
A					t_1	m	l	r	s	d	f			A
	r	s	d	f						t_1	m	l_1	r	
G			t_1	m	l_1	r	s	d	f					G
	d	f						t_1	m	l_1	r	s_1	d	
F	t_1	m	l_1	r	s_1	d	f						t_1	F
E						t_1	m	l_1	r	s_1	d	f_1		E
	l_1	r	s_1	d	f_1						t_1	m_1	l_1	
D				t_1	m_1	l_1	r	s_1	d	f_1				D
	s_1	d	f_1						t_1	m_1	l_1	r_1	s_1	
C		t_1	m_1	l_1	r_1	s_1	d	f_1						C

The following tunes and pieces are intended for further practice in changing to and from first sharp and first flat keys:—

THE PILOT.

Key B♭. DUET. S. C. S. NELSON. *Arranged by* J. S.

{:s_1 |s_1 :-.s_1|s_1 :m |m :-.r |d : .d |l_1 :d |r .d :t_1 .l_1 |s_1 :— |— }

{:m_1 |m_1 :-.f_1|m_1 :s_1 |d :-.s_1|m_1 : .m_1|f_1 :m_1 |r_1 :m_1.fe|s_1 :f_1 |m_1 }

O pi - lot, 'tis a fear - ful night, There's dan - ger on the deep;

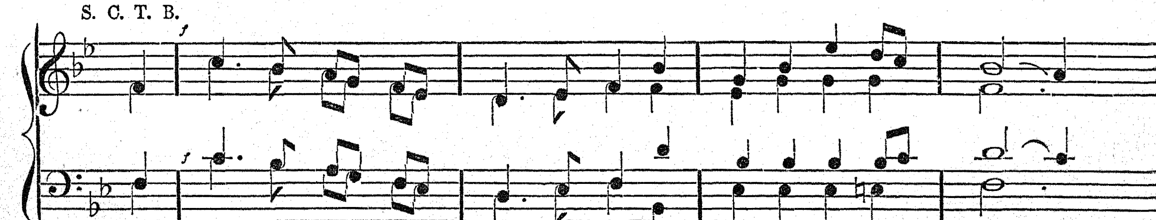


{:s_1 |s_1 :-.s_1|d :m |m :-.r |d :m |r :s_1 .l_1 |t_1 :l_1 ,.s_1|s_1 :— |— ||

{:r_1 |m_1 :-.f_1|m_1 :s_1 |d :-.t_1|l_1 :s_1 |fe_1 :s_1 |r_1 :fe_1.s_1|s_1 :— |— ||

I'll come and pace the deck with thee, I do not dare to sleep.

S. C. T. B.



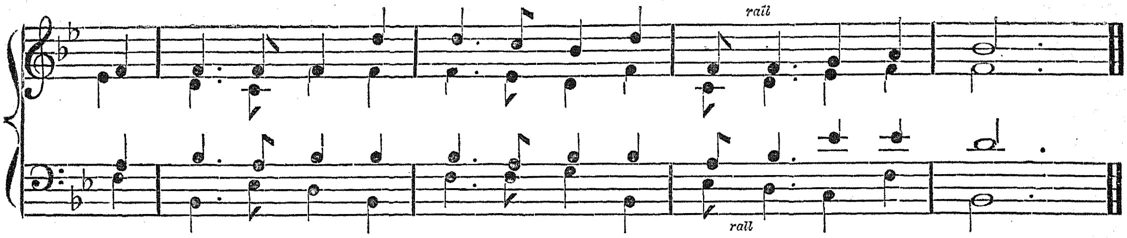
{:s_1 |r :-.d |t_1.l_1 :s_1.f_1 |m_1 :-.f_1|s_1 :d |l_1 :d |f :m.r |d :— |t_1 }

{:s_1 |r :-.d |t_1.l_1 :s_1.f_1 |m_1 :-.f_1|s_1 :s_1 |f_1 :l_1 |l_1 :l_1 |s_1 :— |— }

{:s_1 |r :-.d |t_1.l_1 :s_1.f_1 |m_1 :-.f_1|s_1 :m |d :d |d :d.r |m :— |r }

{:s_1 |r :-.d |t_1.l_1 :s_1.f_1 |m_1 :-.f_1|s_1 :d_1 |f_1 :f_1 |f_1 :fe_1 |s_1 :— |— }

Go down, the sail - or cried, go down; This is no place for thee;



:s$_1$ | s$_1$:- .s$_1$ | s$_1$:m | m :- .r | d :m | s$_1$.s$_1$:— | l$_1$:t$_1$ | d :— | — ||
:f$_1$ | m$_1$:- .r$_1$ | s$_1$:s$_1$ | s$_1$:- .f$_1$ | m$_1$:s$_1$ | r$_1$.m$_1$:— | f$_1$:s$_1$ | s$_1$:— | — ||
:t$_1$ | d :- .t$_1$ | d :d | d :- .t$_1$ | d :d | t$_1$.d :— | f :f | m :— | — ||
:s$_1$ | d$_1$:- .f$_1$ | m$_1$:d$_1$ | s$_1$:- .s$_1$ | l$_1$:d$_1$ | f$_1$.m$_1$:— | r$_1$:s$_1$ | d$_1$:— | — ||

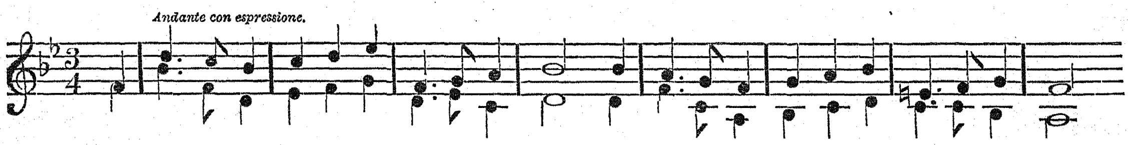
Fear not! but trust in Pro - vi-dence Wher-ev-er thou may'st be.

Ah, pilot, dangers often met
We all are apt to slight,
And thou hast known these raging waves
But to subdue their might.
It is not apathy, he cried,
That gives this strength to me;
Fear not! but trust in Providence,
Wherever thou may'st be.

On such a night the sea engulph'd
My father's lifeless form;
My only brother's boat went down
In just so wild a storm:
And such, perhaps, may be my fate,
But still I'll say to thee,
Fear not! but trust in Providence
Wherever thou may'st be.

THE MITHERLESS BAIRN.

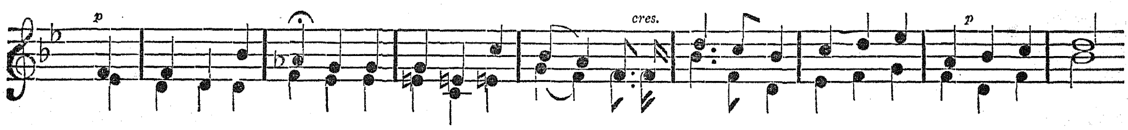
Key B♭. *Words by* WILLIAM THOM. SOLO OR DUET. *Music by* JAS. SNEDDON, MUS. BAC.



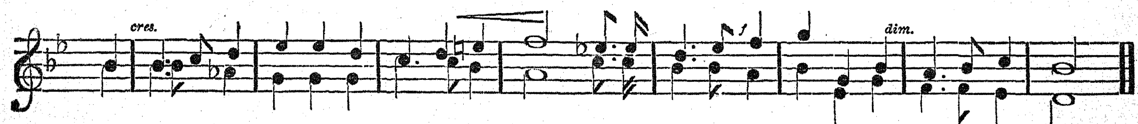
Andante con espressione.

:s$_1$ | m :-.r:d | r :m :f | s$_1$:-.l$_1$:t$_1$ | d :— :d | t$_1$:-.l$_1$:s$_1$ | l$_1$:t$_1$:d | fe$_1$:-.s$_1$:l$_1$ | s$_1$:— }
:s$_1$ | d :-.s$_1$:m$_1$ | f$_1$:s$_1$:l$_1$ | m$_1$:-.f$_1$:r$_1$ | m$_1$:— :m$_1$ | s$_1$:-.r$_1$:t$_2$ | d$_1$:r$_1$:m$_1$ | r$_1$:-.r$_1$:d$_1$ | t$_2$:— }

When a' ither bairnies are hush'd to their hame, By aunt - y, or cousin, or freck - y granddame,



p cres. p
:s$_1$ | s$_1$:m$_1$:d | ta$_1$:l$_1$:l$_1$ | l$_1$:fe$_1$:r | d :t$_1$:-.s$_1$.,s$_1$ | m :-.r:d | r :m :f | t$_1$:d :r | m :— }
:f$_1$ | m$_1$:m$_1$:m$_1$ | s$_1$:f$_1$:f$_1$ | fe$_1$:t$_2$:fe$_1$ | l$_1$:s$_1$:-.s$_1$.,s$_1$ | d :-.s$_1$:m$_1$ | f$_1$:s$_1$:l$_1$ | s$_1$:m$_1$:s$_1$ | d :— }

Wha stands last and lane-ly, and nae-bod-y carin'? 'Tis the puir doited loon-ie, the mith-er-less bairn.

cres. f dim.
:d | d :-.r:m | f :f :m | r :-.m:fe | s :— :f.,f | m :-.f:s | l :l$_1$:d | t$_1$:-.d:r | d :— ||
:d | d :-.d:ta | l$_1$:l$_1$:l$_1$ | r :-.r :d | t$_1$:— :r.,r | d :-.d:t$_1$ | d :f$_1$:l$_1$ | s$_1$:-.s$_1$:f$_1$ | m$_1$:— ||

Wha stands last and lane-ly, and nae - body carin'? 'Tis the puir doited loon-ie, the mith - er-less bairn.

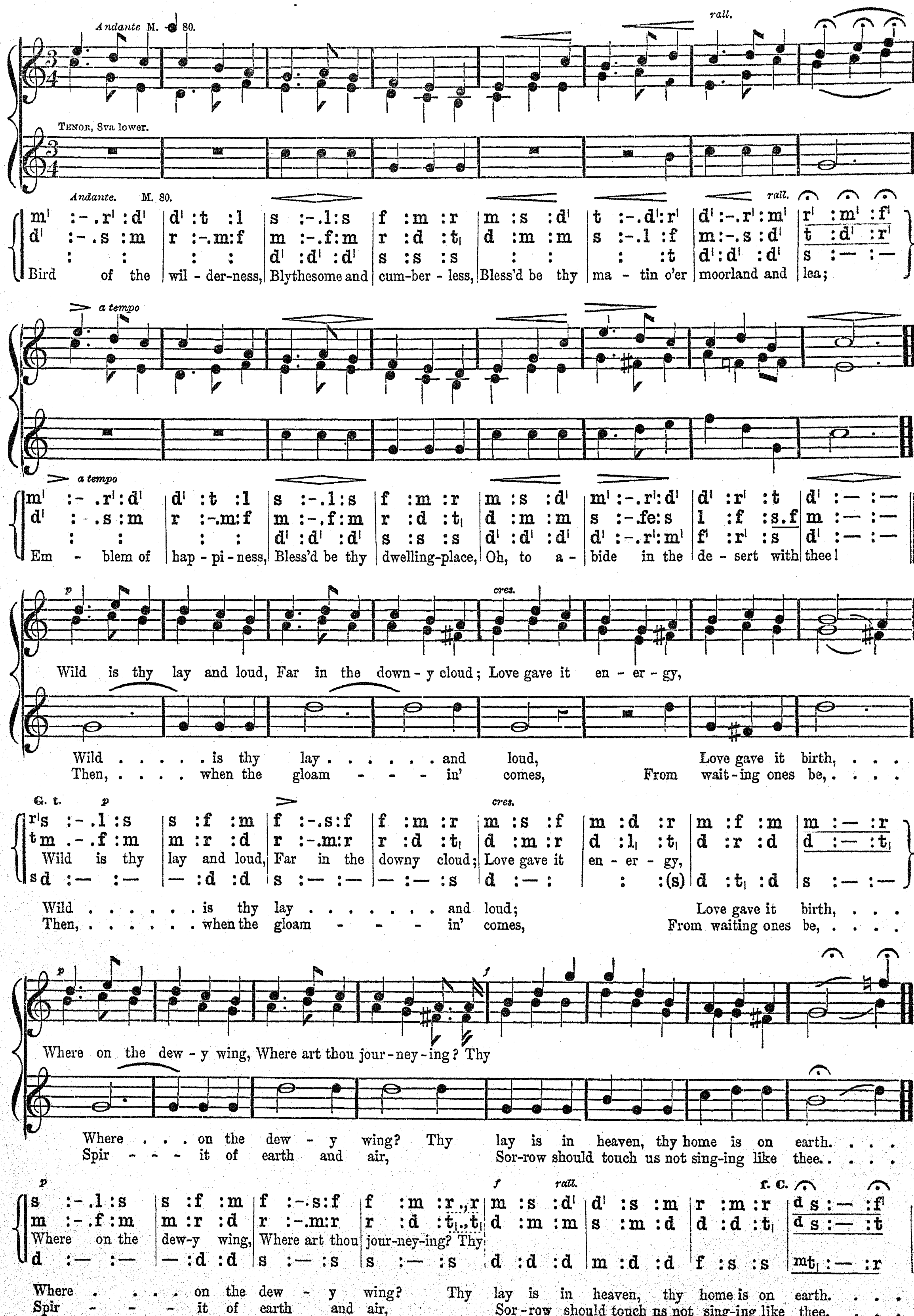
The mitherless bairn gangs to his lane bed,
Nane covers his cauld back or haps his bare head;
His wee hackit heelies are hard as the airn,
An' litheless the lair o' the mitherless bairn.

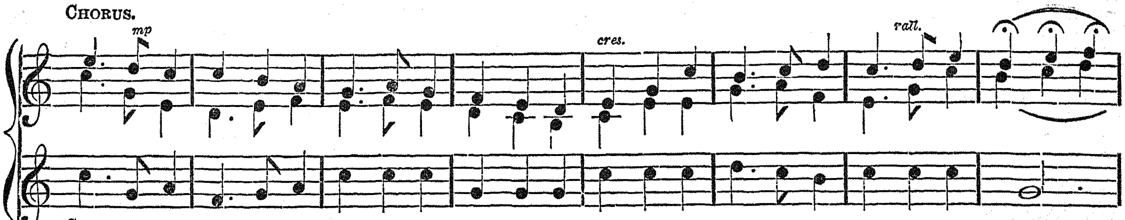
Her spirit, that passed in hour o' his birth,
Still watches his wearisome wand'rings on earth,
Recording in heaven the blessings they earn
Wha couthilie deal wi' the mitherless bairn.

O speak nae him harshly—he trembles the while
He bends to your bidding, and blesses your smile;
In their dark hour o' anguish the heartless shall learn
That God deals the blow for the mitherless bairn.

THE SKYLARK.

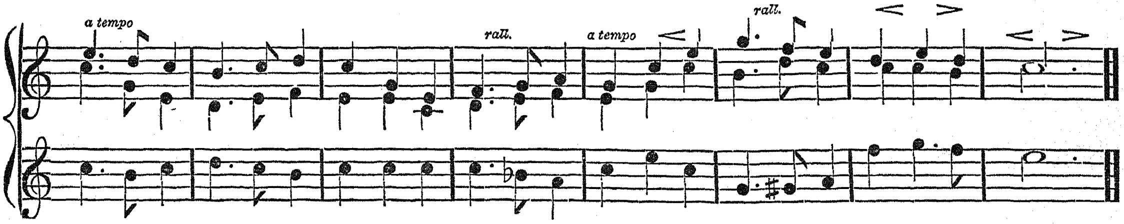
Key C. *Words by* HOGG. TRIO. S. C. T. JAS. SNEDDON, Mus. Bac.





CHORUS.

mp				cres.		rall.	
m' :-.r':d'	d' :t :l	s :-.l:s	f :m :r	m :s :d'	t :-.d':r'	d' :-.r':m'	r' :m' :f'
d' :-.s :m	r :-.m:f	m :-.f:m	r :d :t,	d :m :m	s :-.l :f	m :-.s:d'	t :d' :r'
d' :-.s :l	f :-.s:l	d' :d' :d'	s :s :s	d' :d' :d'	r' :-.d':t	d' :d' :d'	s :— :—
Bird of the	wil - derness,	Blythesome and	cum-ber - less,	Bless'd be thy	ma - tin o'er	moorland and	lea;



a tempo			rall.	a tempo	rall.		
m' :-.r':d'	t :-.d':r'	d' :s :m	f :-.s :l	s :d' :m'	s' :-.f' :m'	r' :m' :r'	d' :— :—
d' :-.s :m	r :-.m:f	m :m :d	r :-.m:f	m :s :d'	t :-.r' :d'	d' :d' :t	d' :— :—
d' :-.t :d'	r' :-.d':t	d' :d' :d'	d' :-.ta:l	d' :m' :d'	s :-.se:l	f' :s' :-.f'	m' :— :—
Em - blem of	hap - piness,	Bless'd be thy	dwelling place,	Oh, to a -	bide in the	de - sert with	thee.

O'er fell and fountain sheen,
O'er moor and mountain green,
O'er the red streamer that heralds the day,
Over the cloudlet dim,
Over the rainbow's rim,
Musical cherub, soar singing away.

Then, when the gloamin' comes,
Low in the heather blooms
Sweet will thy welcome from waiting ones be.
Spirit of earth and air,
Could we thy joyance share,
Sorrow should touch us not singing like thee.

CHORUS.

Note.—The last four lines have been added for this setting by ALEX. NASMYTH, Esq., Dundonald, Fifeshire.

DRAWING—CHAPTER V.

LANDSCAPE.

No branch of art has been more practised or less taught than the art of landscape drawing. Almost all girls and many boys used to be set to draw landscapes at school; and some of these, after their school-days were over, attended classes where similar work was done.

"Sketching" landscapes has been looked upon as a suitable, light occupation for those who would otherwise be utterly idle, and a listless, half-hearted attention to the subject for two hours per week has been considered sufficient study for this branch of art. Applicants for admission to art schools and classes frequently say, "I don't know anything about the drawing which you teach here, but I have learned sketching from nature," as though it were a slight accomplishment which needed no serious study. Modern art education is gradually getting rid of this frivolous and delusive work; and it is our intention to show that in this, as in every branch of art, skill can only be acquired by patient study, and that the best and shortest road to success is to begin at the beginning and master those more elementary studies which have been set before the student in preceding chapters. Every bit of practical work conscientiously done, every scrap of knowledge really acquired in these elementary studies, will be found useful in the more advanced and difficult study of landscape.

Looked at rightly, this is the study of the beauties of the natural world; these beauties are endless, subtle, changeable; above all, they are God-created beauties, infinitely surpassing the most lovely works of man. Surely this is a great study, not to be entered upon lightly as an amusement for idle hours, but worthy of close attention, much previous preparation, and some hard work.

The previous preparation necessary should consist of model or object drawing, light and shade, and some of the elements of perspective. Having some knowledge of these things, the student should go to nature with the intention of earnestly endeavouring to depict some of the simplest and humblest of nature's beauties. It is not necessary to go far afield to find such things; they lie at our very doors, often unnoticed. Those who are so fortunate as to live in lovely districts can find much more than they need; those who are not so fortunate can find enough. The mistake most frequently made by beginners is to attempt too much; they either go themselves, or are taken by their friends, to elevated spots, from whence views can be had over two or three counties, and these views are suggested as suitable subjects for their pencils. Down in the valley is literally and figuratively the proper place for the true student; these "grand views" are only for the expert and experienced artist, and even he will think twice before he attempts them.

The grandeur, the glory of nature, is a thing to admire boundlessly, and to look upon as something to try at some day, but not yet. With all right and high ambition the student must be content to "labour and to wait," to give up, to sacrifice his ambitious desires, and to devote himself to the representation of a small part of the many beauties which present themselves.

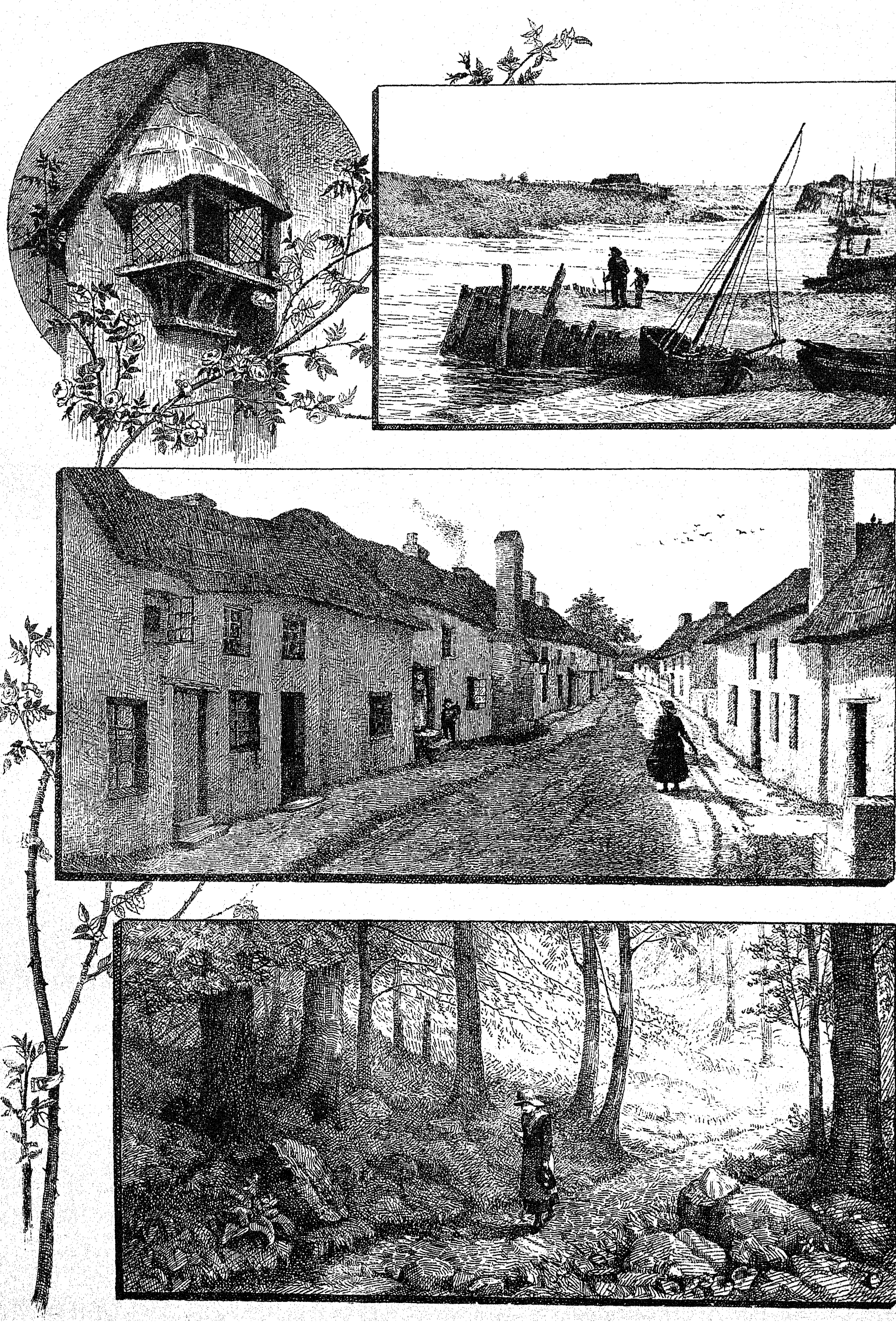
The first drawings should be made in pencil, and for this work very few materials are required: a stool, a sketch-book (or a block), and one or two soft pencils are all that are really needed. A sympathetic friend may be useful, more than one is generally a mistake, and on most occasions it is best to be alone.

The first difficulty which presents itself is the choice of subject. Many a day has been lost in the fruitless endeavour to make this choice, and therefore it will be useful to name certain definite subjects which are suitable for beginners, and which may be found in almost any neighbourhood.

The following may be taken as suggestions. A stile or

DRAWING.

LANDSCAPE.



gate, a tree trunk, a footbridge, a road with its surroundings, a group of beehives (fig. 1), a church porch, or a cottage window (see Plate VI.) It is well to start out with one or two of these subjects (or similar ones) in the mind, and having found one, to sit down to it without hesitation or too much

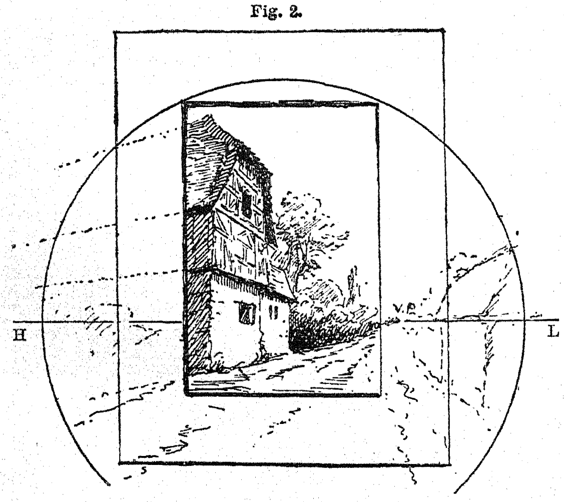
Fig. 1.

criticizing its beauty or its suitability; these qualities will probably be discovered as the drawing goes on.

A point of view has next to be decided upon, and a "perspective" view is the best to choose; that is, not a direct front view or elevation. It will be evident that if a view of the beehives (fig. 1) had been taken right in front, from which position they would appear all in a line, side by side, the sketch would not have been so attractive.

The point of view being decided upon, after some time spent in walking round the subject, the next question is, how much to take? or where to leave off? This is best decided by the use of a card with a hole in it, similar to that shown in fig. 2. By holding this card a short distance from the eye, and looking at the subject through the hole in the centre, all the attractive and distracting surroundings will be cut off, and the cottage or stile alone will be seen. Students of the

Fig. 2.



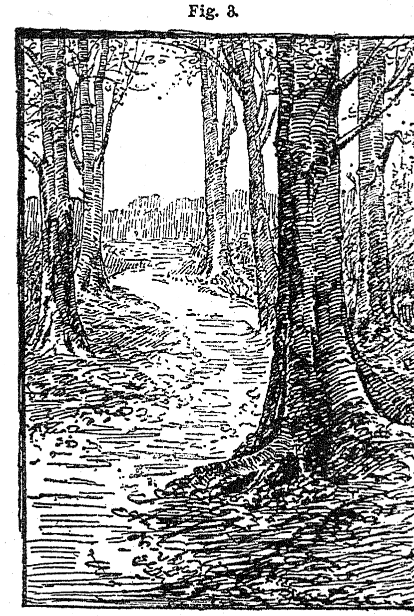
science of perspective should observe that the circle in fig. 2 represents the "field of vision" or "base of the cone of rays;" the lower edge of the opening in the card is the "ground line;" the line marked H L is the "horizontal line," on which one "vanishing point" is marked.

The field of vision includes far too much for a sketch; the less interesting parts are therefore cut off by the card. When the card is held nearer to the eye, the view through the hole will be larger and more extensive; when held some distance away, the view will be contracted. By the use of this simple contrivance a good subject may be got out of very unpromising material. This may be seen by reference to the sketch (fig. 2), where the long uninteresting lines of the side of the cottage, and the equally uninteresting little shed on the opposite side of the road, are cut off, and a fairly interesting little sketch is made out of the front of the cottage, one tree, and a bit of the road. Even when the surroundings are attractive and interesting, it is well to narrow the view and limit the drawing to one or two simple objects, and to draw these objects large in the space which the sketch is to occupy.

This work of selection and arrangement should be done with much thought and care, the main object in view being simplicity; the student must be content to sacrifice—give up—one thing after another that he would like to put into the picture, and at last to limit himself, if possible, to one thing. This one object should be drawn a fairly large size, and should be drawn in just the same manner and with just as much care as the objects given as examples in the chapter on "model drawing."

The "horizontal line" or height of the eye should be determined upon, and the line actually drawn upon the paper—the distance from the top or bottom of sheet will be determined by the subject. In fig. 2 this line (marked H L) is low, only about one-fourth of the whole height; this position is rendered necessary by the decision to include the roof of the cottage. It will be evident that the card might be lowered, more of the road taken in, and the upper portion of the cottage cut off; the horizontal line, which is fixed by the height of the eye, would then be half way—or more than half way—up the sketch. In fig. 3 some such arrangement has been decided upon; the trunks or lower portions of the trees are

Fig. 3.



drawn, the upper portions omitted, and therefore the horizontal line is placed high, only about one-third from the top.

It is necessary that this placing of the horizontal line should be well understood, for in the drawing of any definite objects (such as the houses in the street scene shown in Plate VI.) it is very helpful; in every drawing or picture it represents the height of the eye; in a building, for example, when seen under ordinary circumstances, it would be nearly as high as the top of the door, in a stile or a gate it would probably be just above the gate post; it generally represents about 5 feet 6 inches of actual height.

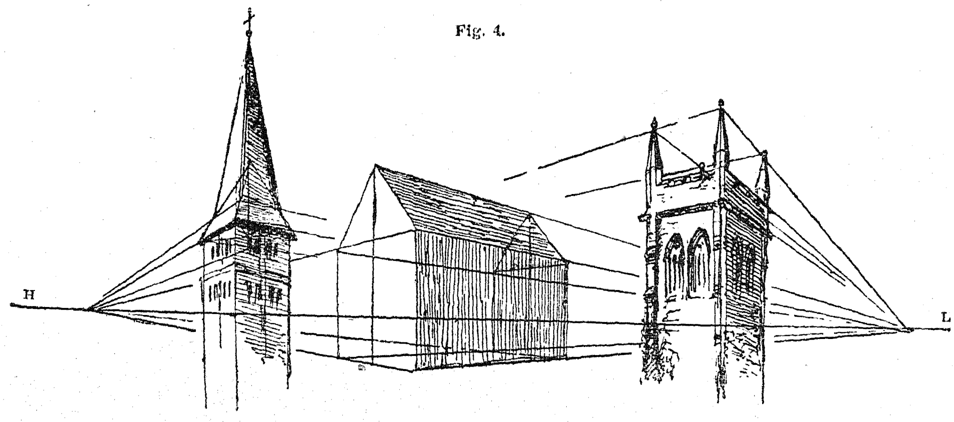
Reference to fig. 4 (and fig. 2) will show the use and value of this line; all the receding horizontal lines of the object will appear to rise or fall towards the horizon, and if any number of these lines are parallel in themselves they will appear to converge to a vanishing point, found by producing a line bounding the object until it meets the horizon. This method of working is plainly shown at fig. 4, the hori-

zontal edges of the tower, the spire, and the block of a house all meeting in vanishing points found on the horizontal line. Similar vanishing points would be found by producing the lines of the houses in the street scene (Plate VI.)

Fig. 4 also shows how useful the model or object drawing is as a preparation for sketching from nature. The block form of the square tower would be nothing more than a square prism; the spire is included in, or made up of, a square prism surmounted by a short square pyramid, and this again surmounted by a tall square pyramid, while the house is only a rectangular prism surmounted by a triangular prism. If these regular solids be correctly drawn the deviations caused by age and accident, and the numerous details, will be found to be comparatively easy. The vanishing points which are shown at fig. 4 cannot always be found on the paper, they will frequently be some distance outside; the converging lines should then be drawn to an imaginary point, as shown at the left of fig. 2.

The application of rules to the drawing of trees and such like forms is less evident than to the drawing of architecture. It would be well to commence the study of trees by drawing the lower portions of the trunks (a somewhat elaborate study of such forms is shown at the bottom of the Plate). These forms are comparatively simple, and they are stationary. The intricate and restless network of the smaller branches is far more difficult to imitate. Tree trunks should be measured up and drawn in exactly the same manner as a group of models. If a group be attempted

Fig. 4.



such as that shown in fig. 3, the largest trunk should be first drawn, and the comparative size of the others, as well as their position in relation to each other, very carefully imitated.

Leonardo da Vinci, one of the great old masters, says that the first thing a young artist should learn is "how to put things in their proper place, and show their proper size." In a subject like that which is shown at fig. 3 this difficulty is presented in a simple form; the tree trunks were really about the same thickness, and most beginners would make them more nearly alike, not daring to show the immense difference in the apparent size of the near trunk and those behind it. This error can be avoided and the proper relation ascertained by a careful measurement and comparison, made by holding the pencil between the eye and the object, as described in chapter on model drawing (p. 372).

The above remarks would apply equally to the beehives in fig. 1. The nearest (and apparently largest) should be drawn first, and the others grouped round it in proper relation both as to size and position. The drawing of trees is a much more difficult task. It is best to begin by drawing them without the foliage, when the growth of the branches can be seen. Each tree has its own peculiar manner of branching, the beech, the oak, and the elm having a special character peculiar to itself. This character should be studied, as even when the tree is covered with summer foliage the forms of the masses of the leaves are all influenced, even produced, by the character of the branching.

We have hitherto confined ourselves to a consideration of the *forms* of natural objects. We shall now speak of the *tones* or values of these objects, leaving the more interesting but infinitely more difficult subject of *colour* for the next chapter.

To sketch in black and white from nature it will be best to choose the blacklead pencil as an instrument. Charcoal, or chalk, or the brush may be used; more complete and powerful work can be done with these than with the pencil, but they are far more difficult to manage. A soft pencil is, therefore, the most suitable implement to begin with, and with this alone very delicate and beautiful work can be done. The outline having been lightly and carefully drawn, the relative tones of the objects in the sketch should be just as carefully studied as the relative sizes. Great errors are frequently made in this part of the work, and even teachers of art and writers upon this subject recommend a quite arbitrary arrangement of light and shade, and give rules for the placing of the "highest light" in one part of the sketch and the "deepest dark" in another. The true student should have nothing to do with such rules, but should try for a long time to imitate as far as possible the real tones of natural objects, very carefully comparing their relative value. It is impossible for anyone to say what is the actual tone of a natural object; it would be folly to attempt to imitate what

Fig. 5.

we might conceive to be the real tones: our scale or range of tones is far too limited to allow us to imitate the infinite variety of nature, but we can, by careful study, get pretty near to the relative value of these tones.

In fig. 5 an attempt has been made to give the effect of a wooded landscape and a brilliant sunset sky reflected in the quiet waters of a stream; the reflection of the sky is left white. This only represents a fraction of the brilliancy of nature. Yet we have no lighter tone than white; we must, therefore, be content to represent brightness or light by the tone of the white paper, and then get, as far as possible, the relative tones of the objects. The scale of nature being

almost, if not quite, infinite, and our scale of possible tones being very limited, it is evident that we must again generalize and simplify. This can best be done by looking at nature with half-closed eyes, and so getting rid of much detail and many small variations of shade, only seeing the larger and more definite gradations.

In practical work also we shall find that we have to make one tone do duty for many parts of our drawing which quite evidently differ in tone. These are necessary limitations under which we must work and do our best, and it is well to frankly recognize these limitations, as any attempt, however earnest, to represent all the forms or all the shades which we see before us in nature must result in failure and disappointment.

When working these shades or tones with the pencil the student should begin at the one end of the scale or the other, putting in the tenderest tones with a soft, light, broad touch, or carefully drawing the outline of the darkest shadows, and filling these in strongly, leaving the edges distinct, yet not hard. Great care should be taken not to have too much difference between the shades, or else the limit of the scale will be reached too soon, and a need will be felt for something darker than black to represent the deepest shades; by great care in this respect sufficient gradation, strength, and variety should be secured without ever reaching positive blackness, even in the darkest parts of the drawing.

A gray day is better suited for sketching than a bright one. In gray weather the shadows may be indefinite, but they are fairly constant, whilst on a sunny day they are continually changing, and in a few hours the light and shade will be almost wholly reversed. If a sketch be attempted of a scene in sunlight, like the street scene on Plate VI., the shadows should be very carefully drawn, and the whole sketch completed in about two hours, or taken up again at about the same time on the next sunny day.

We have pointed out in this chapter the necessity for choosing simple subjects, and also some of the limitations under which it is necessary to work when imitating these subjects. But while the student is patiently and humbly working at the stile or the footbridge the glories and wonders of nature need not pass unnoticed; he can watch the ever-changing light and shade of a spring morning, the full beauty and brightness of a summer day, or the passing gleam of autumn sunshine in the faded woods; and if he cannot depict these things he will learn something about them, and will carry away in his heart and mind that which will be far more precious than his sketch.

TRIGONOMETRY.—CHAPTER VII.

OBLIQUE-ANGLED TRIANGLES—THE LAWS OF THEIR CONSTRUCTION—THE SOLUTION OF THEIR CASES.

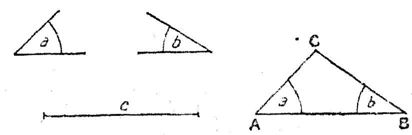
EVERY triangle is either (1) right-angled or (2) the sum of two right angles. A triangle cannot be formed of any three [given] straight lines. Such a figure can only be made when the sum of any two of the sides is greater than the third. The *perimeter* of a triangle is the sum of its three sides. If any one of the angles of a triangle is *obtuse*, the triangle is an obtuse-angled triangle. No triangle can have more than one obtuse angle. Of all triangles which have precisely the same angles, the proportions of the sides are the same. When a triangle is before us we may regard any one of the three straight lines which form it as the *base* on which it stands, and then the two remaining lines are the *two sides*. The *vertex* is the point at which these *two sides* meet, and may be designated as (1) the angle opposite to the base, or (2) the angle contained by the two sides. The other angles, which are not the vertex, are called the angles at the base, and each of them is opposite to one of the two sides. In every triangle the greater side of any two is opposite to or subtends the greater angle—that is, of course, the obtuse one in an obtuse-angled triangle. It was shown at p. 377, that any side of a triangle may be considered as the *radius* of a circle, and that the other sides will necessarily then become, as the case may be, either sines, tangents, or secants, and these give, as a matter of course, respectively, their *reciprocals*—viz. cosecant, cotangent, and cosine.

These preliminaries being recalled to memory and adjusted in thought, we can now proceed to consider the trigonometrical cases possible in regard to oblique-angled triangles. These are as follows—viz. when there are given the following parts as the means of finding the remaining parts of the triangle: (1) two angles and a side, (2) two sides and an angle opposite to one of them, (3) two sides and the angle included or contained by them, and (4) three sides.

We shall first of all, for simplicity's sake, show the proper method of construction to be adopted in producing these different forms of triangle, and we shall next explain the mode of making trigonometrical calculations in each case.

1. To construct a triangle, there being given two angles and one side.

Let the given side be c, taken as the base, and the two given angles a and b respectively. It is at once seen that these two given angles may either be (1) the two angles adjacent to the side c, or (2) the vertical angle and one of the adjacent angles. (1) We shall consider a and b given as



adjacent angles to the given side c. Draw the straight line A B equal to c. At the one extremity A, draw the straight line A C, making with the straight line A B an angle equal to the given angle a (either by the use of the line of chords or of a protractor, as may be found most convenient). From the other extremity B, draw the straight line B C, making with A B an angle equal to the given angle b. If necessary, produce the lines A C and B C till they cut each other, and the point C, in which these two lines intersect one another, is the vertex of the triangle A C B, and the two lines A C, B C, are the two sides of it, and complete the triangle as required. This they will necessarily do, if, as is implied in the term oblique-angled triangle, the sum of the two given angles a and b is less than that of two right angles.

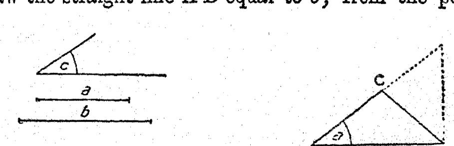
(2) The construction in case second is to be arranged at either extremity of the line c, in accordance with Euclid I. 32. This proposition—unless the learner is thoroughly acquainted with the principle it teaches and the construction it requires—should be carefully restudied. It will not be without benefit to the student to read the matter on triangles given at pp. 621, 622. To this construction we shall, at a subsequent stage, recur.

2. To construct a complete triangle, there being given (1) two sides, a and b, and (2) an angle c, *contained* by them.

Draw the straight line A B, equal to b, and at the point A in A B draw A C, making, with A B, the angle B A C equal to angle c; measure off on this straight line A C (Euclid, I. 3), a part A C equal to a. Then from the point C draw C B, joining C and B, and the triangle is complete—the third side B C and the two angles A C B, C B A, being thus found as required.

3. To construct a triangle when two sides, a and b, and an *opposite* angle to one of them, c, is given.

Draw the straight line A B equal to b; from the point A



draw A C, making the angle B A C equal to the given angle c; then with B as centre, and radius equal to a, describe an arc. If at any point, as C, this arc intersects A C, by joining B and C the triangle will be completed, and the side B C as well as the angles A C B and C B A have been found.

It is not, however, with every triangle that this form of

solving the problem is possible: for (1) when the *given* side opposite to the *given* angle is greater than the other given side, the angle opposite to that other and less side is always acute; but (2) when the *given* side opposite to the *given* angle is less than the other given side, the angle opposite that other given and greater side may be either acute or obtuse, and consequently is ambiguous as a trigonometrical factor, for trigonometry gives us only the *sine* of an angle—not the angle itself. The sine of every angle, however, is also the *sine* of its supplement. As the logarithmic tables only give the *acute* value of an angle, and the *obtuse* value thereof is its supplement, we must attend to the conditions of the problem if we wish to construct the triangle rightly, and to have its value a determinate one. To this subject, however, it will be necessary to return.

4. To construct a triangle, the three sides, a, b, and c, being given.

The *given* sides are a, b, and c, of which one, a, must be

less than the sum and greater than the difference of the other two sides, b and c. Draw the straight line, A B, equal to a. Taking the point A as centre and radius, equal to b, describe an arc above A B. Again, taking the point B as centre and radius, equal to c, describe another arc above A B. From the point C, where these arcs intersect, draw the straight lines C A, C B, and the required angle, A B C, will be constructed.

These are the typical geometrical constructions which require to be made in order to obtain the solution of oblique-angled triangles in all these different cases. We shall show the method of dealing with these logarithmically, and subsequently explain the more modern method of working them out algebraically. For we must recollect that the older trigonometrists had no excellently perfected system of arithmetic—that their system of algebra was not yet wrought out into distinctness. Instead of applying algebra to the solution of problems in geometry, almost all their knowledge of algebra was derived, by deduction, from geometry. The real connection of geometrical and algebraic signification and expression in resolving determinate problems is now so much more clearly seen and understood that, in many ways besides working such questions as these, the geometrical mode has been rivalled, where not superseded, by the algebraic.

We require here again to ask the student to take for granted the accuracy of the logarithmic numbers employed in these calculations. They can be tested by the tables.

CASE I.—Given (1) the angle A, 49° 25′, (2) the angle C, 63° 48′, and (3) the side AB, 275′.

The three angles of a triangle = 180°, from which subtract 49° 25′ + 63° 48′ = 66° 47′, for angle B as first *Ans.*

Now any two sides of a triangle are as the sines of the angles opposite to them, hence sine C is to sine A as is A B to B C; that is—

Sin 63° 48′ : sin 49° 25′ : : 275 : B C.

Log sin 49° 25′ + log 275 =	12·3198379
" 63° 48′ =	9·9529175
	2·3669204

Log B C = 232·7665; second *Ans.*

Again, sine C is to sine B as is A B to A C; that is—

Sin 63° 48′ : sin 66° 47′ : : 275 : A C.

Log sin 66° 47′ + log 275 =	12·4026580
" 63° 48′ + =	9·9529175
	2·4497405

Log A C = 281·67; third *Ans.*

CASE II.—Given (1) the two sides A C and A B, respectively 133 and 176, and (2) the angle at A, 73° 16′; to find the remaining parts, viz.:—the angle at C and B and the side C B.

(1) Add and subtract the sides to get their sum and difference. (2) Subtract the angle from 180°, and take half the remainder to find half the sum of the unknown angles. Then (3) say, as the sum of the sides is to their difference, so is the tangent of half the sum of the unknown angles to the tangent of half their difference. Half the difference having been thus found, (4) add to it the half sum to find the angle opposite to the greater side, and (5) subtract it to get the less angle. This being done, (6) the third side is found as in the previous case. That is, we proceed thus:—

(It is of great importance that the student should follow and comprehend the operations process by process.)

A B + A C (*i.e.* 176 + 133 = 309) : A B − A C (*i.e.* 176 − 133 = 43) : : tan $\frac{1}{2}$ (C + B) : tan $\frac{1}{2}$ (C − B), viz., 180° − 73° 16′ = 106° 44′ ÷ $\frac{1}{2}$ = 53° 22′. Of these the logarithms stand thus:—

A B − A C = 43	Log	1·633468
Tan $\frac{1}{2}$ (180° − A) 53° 22′	"	10·128679
		11·762147
A B + A C = 309	"	2·489958
∴ Tan $\frac{1}{2}$ (C − B) 10′ 36″		9·272189

This half-difference being added to the half-sum gives 10° 36′ + 53° 22′ = 63° 58′ as the angle opposite to the greater side, *i.e.* C.

And this half-difference being subtracted from the half-sum gives 53° 22′ − 10° 36′ = 42° 46′ as the less angle, *i.e.* B.

The angles, therefore, are A 73° 16′, B 42° 46′, C 63° 58′ = 180°.

Next, as in Case I., the third side, B C, is found thus:—Sine C : sine B : : A B : B C.

Arranged logarithmically these stand as follows:—

Sine A 73° 16′ + log 176 =	{ 9·981209 { 2·245513
	12·226722
Sine C 63° 58′	9·953537
Log C B 187·58 (*i.e.* the third side)	2·273185

CASE III.—Given the three sides A B, B C, and A C, respectively equal to 98, 95·12, and 162·34; to find the three angles.

In this question we add the three sides, and from half the sum subtract the side *opposite* to the angle sought, say A, *i.e.* 98 + 95·12 + 162·34 = 355·46 ÷ $\frac{1}{2}$ = 177·73 − 162·34 = 15·39, of which the logarithm is 1·18724.

Next from half the sum of the same three sides we subtract the side containing the angle sought—viz. A B—which gives us (177·73 − 98 =) 79·73, the logarithm of which is 1·90162.

These two logarithms we sum, adding the two index tens (*i.e.* 20), making a total of . . . . 23·08886

We take now (1) the logarithm of the half-sum, *i.e.* 177·73 = log 2·24976

and (2) the logarithm of that half-sum, less B C, *i.e.* 177·73 − 95·12 = 82·61 = log 1·91703

These being added together yield a total of . . . 4·16679

This we subtract from the summation formerly made, and get . . . . 18·92207

Half this sum (*i.e.* 9·46603) is the log cos 16° 7′ 27″ of half the angle sought, which, having been multiplied by 2, gives for angle A 32° 14′ 54″, *Ans.*

The answers to the other cases are obtained by Case I. The whole calculation may be shown thus—

$$\left\{\begin{array}{l} \frac{1}{2}(AC+AB+BC)-AC=15{\cdot}39 \text{ log } 1{\cdot}18724 \\ \frac{1}{2}(AC+AB+BC)-AB=79{\cdot}73 \text{ `` } 1{\cdot}90162 \end{array}\right\} +20=23{\cdot}08886$$

$$\left\{\begin{array}{l} \frac{1}{2}(AC+AB+BC)= \quad 177{\cdot}73 \text{ `` } 2{\cdot}24976 \\ \frac{1}{2}(AC+AB+BC)-BC=82{\cdot}61 \text{ `` } 1{\cdot}91703 \end{array}\right\} \qquad 4{\cdot}16679$$

$$\begin{array}{r} 2)\underline{18{\cdot}92207} \\ 9{\cdot}46103= \\ 16^\circ\ 7'\ 27'' \\ 2 \\ \hline \end{array}$$

Ans. Angle A, 32° 14′ 54″

There are various other modes of solving the [possible] cases in trigonometry. Indeed some excellent authorities on this subject make no distinction between right-angled and oblique-angled triangles. To some other cases, and to the algebraic expressions and operations required in their solution, we shall direct the attention of the student in the sequel.

HISTORY OF GREAT BRITAIN AND IRELAND.

CHAPTER VI.

HENRY II.—RICHARD I.—JOHN.

Henry of Anjou, the great-grandson of the Conqueror, was resident in Normandy, and had not yet completed his twenty-second year when, by the death of Stephen, he became the first of the Plantagenet dynasty of England's sovereigns. Matilda had held and kept for him the duchy of Normandy. His father's demise had made him, in 1150, lord of Anjou and Maine. By marriage he had acquired Poitou, Gascony, and the largest and best parts of Aquitaine. The treaty of 1153 formed his passport to the vacant throne, and civil broil offered no resistance. He had been an apt student of the craft of statesmanship. He surrounded himself with all the material aids of power, and fashioned his court according to such arrangements as best fitted the exercise of a despot's iron rule. The influence of money he knew, and he was cunning in the art of using it politicly and politically. He enjoyed intrigue and negotiation, the management of men, the ordering of events. In person he was of middle height, large-headed, ruddy of countenance, gray-eyed, broad-chested, fond of exercise, yet tending to corpulency, moderate in drink and diet, immoderate in amours, penurious in private, in public profuse, inclined to literature, and, though not well-voiced, eloquent. During the latter half of the twelfth century he had a large share in most of the mightiest movements.

Owing to stress of weather Henry did not reach England till 8th December, yet life, peace, and property were respected. On landing near Southampton, the king first visited Henry of Winchester. Richard De Lacy was continued as minister, Theobald of Canterbury was taken as adviser, and Thomas A'Becket, Theobald's secretary, was made chancellor. Becket was the friend and confidant of Nicolas Breakspear, that monk of St. Alban's who, as Adrian IV.—the only Englishman who wore the tiara—had just gone to fill the papal throne. Henry was crowned on the 19th December, 1154; held a great court and council within a week at Bermondsey; appointed Nigel, bishop of Ely, over the exchequer; dismissed all foreign mercenaries, and commanded all castles built in Stephen's time to be demolished; degraded the earls who derived their titles from Stephen or Matilda, resumed possession of the royal estates, and restored the ancient judicature of the realm. At the council of Wallingford he gained the acknowledgment of his son William as his successor, and at that of Winchester he proposed the conquest of Ireland and the founding therein of a kingdom for his brother William. Pope Adrian IV.—to whom special ambassadors had been sent—willing to round off Western Christendom, readily sanctioned Henry's scheme for the annexation of Ireland, and confirmed that kingdom to him, provided Peter's pence were paid, submission to the Holy See preserved, and the rights of the clergy held inviolate and unimpaired. The king did not then prosecute his design on Ireland, and Alexander III. confirmed this famous Bull. The Welsh were still in arms; the northern counties were yet ruled by the founder of Holyrood; and there was enough for him to do in Anjou and Normandy. He spent a year in settling his continental affairs.

On his return he proceeded to kingly business. Hugh Bigot was humbled, and from William of Warrenne he wrested the Norfolk estates, and held many provincial courts to receive the homage of his courtiers. In July, 1157, at Northampton, Henry's first Welsh war—ostensibly to mediate in a feud between the two princely brothers Owen Gwynneth and Cadwallader—was arranged. At Coleshill, near Flint, the Cymry resisted the passage of Henry's army. Though the Constable of England, Henry of Essex, by accident, as he averred, let the royal standard fall, and under the impression that the battle was lost and the sovereign slain confusion prevailed, the king rallied his forces, and marched on to Rhuddlan Castle on the east bank of the Clwyd. Thence Henry proceeded to Nottingham, whither Malcolm IV. of Scotland had advanced, and arranged with him for the surrender of the northern counties. He held his Christmas feast at Lincoln, and early in 1158 he visited Cumberland, put the government of the north in good order, and by midsummer, at Carlisle, knighted William De Warrenne. In August he set out for the Continent, and there he remained till January, 1163.

During this long interval the king's chief justiciars, Richard De Lacy and Robert of Leicester—using the child-prince Henry (born 1155) at ceremonials occasionally—governed the land, and there was peace within its borders. In 1160 a treaty of marriage was arranged by Henry, at Bourges, between his ward Margaret of France and his son Prince Henry, both being mere children. Theobald of Canterbury died in 1161, and on Whitsunday, 1162, Thomas A'Becket was consecrated his successor, at which time the king caused all the nobles to swear fealty to his son Henry.

Becket was the son of a London merchant, almost certainly of Norman blood. He was rather fond of show, possessed of great wealth, an astute financier and diplomatist, yet withal a most faithful and laborious minister of the crown. When, however, he became head of the church he was as powerful, but less pliant. Henry felt that the pretensions of the church had reached a height which threatened danger to the healthy development of society, by creating a priesthood set free from the ordinary relations and obligations of citizen life, and endeavoured to embody in "The Constitutions of Clarendon" (1164) what Becket himself, though reluctantly, admitted was the ancient law as well as the use and wont of the kingdom—that the clergy were subject to secular jurisdiction, should do homage for their temporalities, should not leave the realm without legal leave, and ought to excommunicate no tenant-in-chief; that appeals should lie from spiritual courts to the king, and that the king should approve of any bishop prior to his institution. The Pope, when these were sent for ratification, instigated, it was thought, by Becket, annulled them, and the prelate apologized for his consenting to them. Henry on this, instead of acting as a constitutional sovereign and maintaining the law, became a wreaker out of personal revenge, and transformed the rebel into a victim and a martyr. On pretext after pretext he fined Becket, and confiscated his goods and gear. The primate fled to the Continent, and was treated with much consideration by princes and the Pope. Henry had Prince Henry crowned by Roger of Pont l'Évêque, archbishop of York. The Archbishop of Canterbury resented this usurpation of his rights. He procured a sentence of excommunication against those who had assisted at that ceremony, and hastened to England. Henry, then in Normandy, when he heard of this, rashly, though passionately, exclaimed, "Will none of those who eat my bread rid me of this pestilent priest!" Four gentlemen of the court, personal foes of the primate, heard the words, took them as a hint, and setting out for Canterbury, rushed

upon him while he was standing by the altar of St. Benedict, and ruthlessly slew him 29th December, 1170; and this day has since been held as a church festival at the splendid shrine of St. Thomas, prepared in 1220 for the reception of the body of the martyr-saint, canonized 3rd March, 1173, by Alexander III. Henry, under fear of excommunication, conciliated the Pope; and subsequently (1172) renounced the Constitutions of Clarendon, declared for Alexander III. as pope, in opposition to the antipope Calixtus, and having purged himself of the guilt of Becket's death received the church's absolution. Then a sort of general peace ensued.

While these events were running their course, Henry, whose designs on Ireland had become known, had received from Dermot, king of Leinster, an offer to hold Ireland as a fief of the English crown, and do homage for it, if aided to conquer it by the subjugation of the other four kings. Henry declined to give armed help, but encouraged him by recommending an application to Richard de Clare (Strongbow). This Richard of Chepstow, with Fitz-Gerald and Fitz-Stephen, two of the illegitimate sons of Henry I. by Nesta, made a descent at Wexford on 24th June, 1164, and effected a landing. Henry himself invaded Ireland 18th October, 1171, was acknowledged king 12th November, and left it 17th April, 1172, for Normandy. Though nominally bearing the title of Lord Paramount of Ireland, the English sovereign rule in that country was exercised within very narrow limits. The king's subjects, or those in the English Pale, were much fewer than the king's rebels—those chiefs who wielded an almost independent power over their septs or tribes—or the king's enemies, the native Irish.

Prompted by their mother and Louis VII. of France, Henry, Richard, and Geoffrey, the king's sons, waged a succession of petty wars against their father, finding allies in William of Scotland and the Earl of Flanders. Henry resolved to propitiate heaven by a public act of penitence, walked barefoot to Canterbury, spent a night in prayer, and next day, 13th July, 1174, bared his back to the scourge of the monks. On that very day, at Alnwick, his formidable foe, the Lion-King of Scotland, was taken captive by surprise, and having been carried to Normandy, subsequently did homage for his kingdom at Falaise on 8th December. In 1178 Henry and Louis made peace, and resolved on undertaking a crusade together. This was done, by proxy, through their sons Philip Augustus and Richard Cœur-de-Lion.

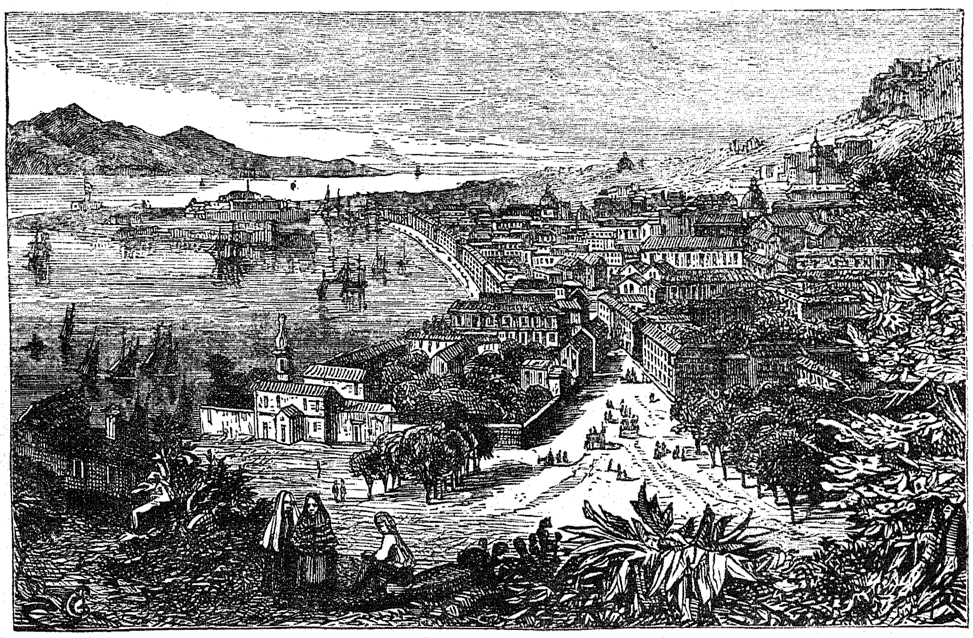
Norwich.

Conspiracies and wars were continued by the king's sons. Though Henry died in 1183, and Geoffrey was killed in a tournament at Paris, Richard and John maintained the revolt, and fortune forsook the old king. The ablest of the Capetians, Philip Augustus, who, on the demise of Louis, had gained the throne of France, made a league with Richard, town after town yielded to them, and at length Henry, expelled from Touraine, submitted to hard terms of peace on 14th January, 1189. Henry, shaken in health and broken in spirit, retired to his castle of Chinon, and, after a period of hopeless sorrow, turned his face to the wall, exclaiming "Let things go as they will," and died on 6th July, 1189. He was interred with little ceremony at Fontevraud in Anjou.

Richard Lion-heart, though King of England, exercised little sovereignty in it. Before his father's death he had resolved to take part in the Third Crusade, and his known earnestness in this cause led him to use reckless and violent means to equip his forces for that holy war. On 20th July he was accepted as King of Normandy. He released his mother Eleanor from her imprisonment, and made her Regent in England, where he was crowned 3rd September, 1189. On his brother John he conferred the Earldom of Mortaigne, with large estates; he sold the Earldom of Northumberland to the Bishop of Durham; disposed of the homage of the Scottish king and the castles on the Borders held by the English for 10,000 marks; extorted a heavy fine from his (illegitimate) brother Geoffrey, who had without his permission entered on the office of Archbishop of York; alienated the crown lands; exposed for sale the chief offices in the kingdom, and would have, he said, sold London if he could have found a purchaser. The Jews in England, knowing Richard's thirst for gold, brought costly gifts to the new sovereign. The clergy and their retainers extruded them from the festal halls, and a horrible massacre of the Jews took place in London, which was imitated at Lynn, Stam-

ford, Lincoln, Norwich, and (accompanied with terrible atrocities) at York, where many, besieged by the populace, put their wives and children to death, set fire to their treasures, and committed suicide by throwing themselves on the blazing heap (1190). Richard I., though born at Oxford [or Woodstock], was little known in England, which he had only visited for short periods, twice or thrice, and as her king he was to be to her little more than a name and a historical connecting link between England and the Continent. His place was filled by able administrators; but the tall, handsome, ruddy, auburn-locked, warlike, impulsive paragon of adventure and romance was personally—except as the hero of marvellous stories—more of a myth than a reality. Before his departure for Jerusalem, in December, 1189, Richard appointed William Longchamp, a Norman bishop of Ely, chancellor of the kingdom and (along with a council of justiciars) regent during his absence, and bound over his brothers John and Geoffrey to remain out of England for three years. From that time till his return as a dearly-ransomed captive, 13th March, 1194, he was the hero of an epic of deeds, mischances, and sufferings.

Early in 1190 the regent and Hugh de Pinset, bishop of Durham, quarrelled at the Exchequer. Longchamp carried his case to the king, the bishop followed. When, on the latter's return, royal letters were presented to Longchamp, he arrested Hugh; and, having meanwhile been appointed papal legate, the regent became practically sovereign, and exerted his power tyrannously. While, in 1191, Eleanor went to Messina with Berengaria, sister of Sancho of Navarre, whom Richard married at Limasol, 13th May, and took with him to the Holy Land, Longchamp raised the anger of John by advocating the claims of Prince Arthur as Richard's heir. In hot fury John came to England, kept royal state in Lancaster, and, taking advantage of the discontent of the nation, presented himself as the protector of the people against Longchamp's exactions, especially contesting his right to hold the castles of England for the king. The regent was in the western counties enforcing his demands. Gerard Camivill, sheriff of Lincoln and warden of its castle, appealed to John, as liege lord, for aid against Longchamp, who had ordained him to surrender his wardenship. John seized the strong castles of Nottingham



Messina.

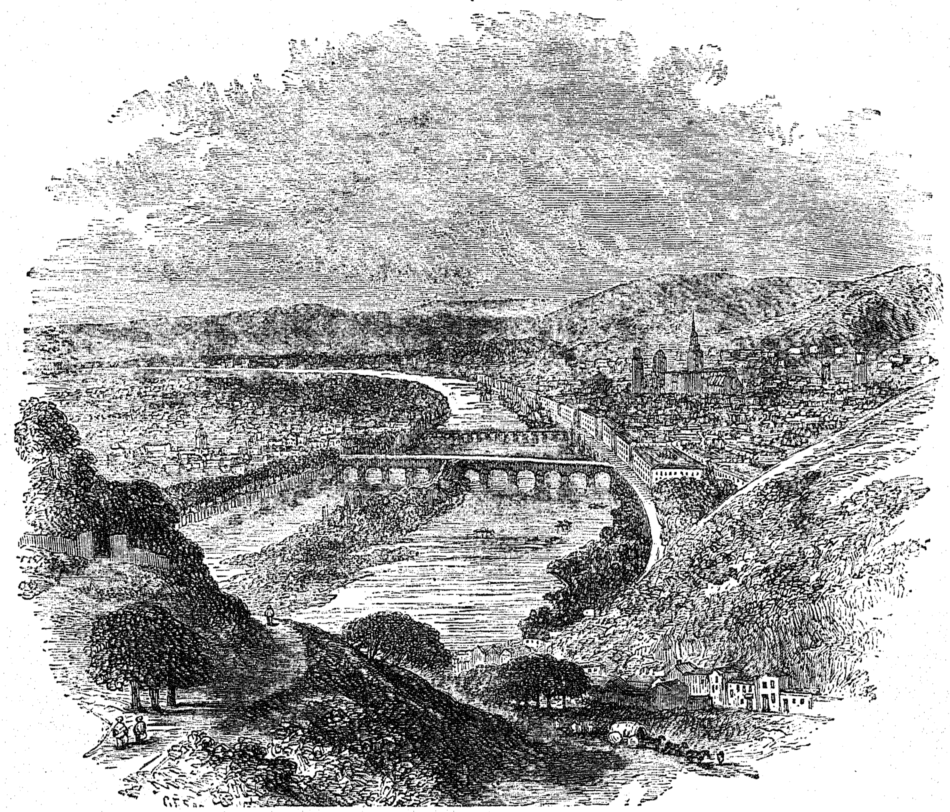
and Tickhill, and serious consequences threatened to arise. Richard, hearing of these, sent from Messina the Archbishop of Rouen as an intermediary power. He, without producing his instructions, brought about peace, and the castles were all put into royalist hands. But Geoffrey, who had recently been consecrated at Tours, attempting to land at Dover, was seized and imprisoned. John compelled his release. Longchamp was exiled. John next unscrupulously intrigued with Philip and with Longchamp, taking bribes from both. Suddenly the capture of Richard I. at Erperg, and his imprisonment in the Tyrol, surprised Europe. Then John and Philip agreed to prevent Richard's release, and so secure the throne to John. The nation stood nobly by their sovereign. To a fourth of their goods they taxed themselves to ransom him, and at length he was set free. On his arrival at Sandwich, 13th March, Richard confiscated John's possessions, and set off to punish Philip's perfidy. He drove the French from Normandy, Touraine, and Maine, and seized the national records of France. Enormous sums were raised by Hubert, archbishop of Canterbury, to carry on the war. William Fitzosborne inflamed London against doing so much for an absentee king; but on a tumult resulting, he was seized and executed, 1196. After an ineffectual armistice, and two indecisive actions at Gisors, 28th October, the papal legate negotiated a five years' truce. Richard secured the throne of Germany to Otho of Saxony, drew John to his side, gained William the Lion for an ally, and seemed sure of waging a successful war against Philip. Only, hearing that his vassal Vidomar of Limoges had found an immense buried treasure, Richard demanded his share. It did not satisfy him. Enforcing his demand for more, Richard invested Chalus-Chabrol. From one of the tower windows of this castle Peter de Basile shot an arrow from a crossbow, which struck the king in the shoulder. The wound gangrened. After an illness of twelve days, during which he forgave all his enemies, bade a tender farewell to his mother, ordered Peter de Basile to be pardoned, left his jewels to Otho, declared John his successor, made a seven-years' shrift, and received the sacrament, he died 8th April. His body was buried in Fontevraud, and his heart in Rouen, to which city he bequeathed it. Of a ten years' reign, he spent scarcely ten months in England. His [illegitimate] son, Philip of Cuinac, slew the Viscount of Limoges, and Llewellyn [ap Jorwerth] married a daughter of his named Isabel. Richard had no issue by Berengaria, who survived till 1230.

John, surnamed (because he held no fiefs as his brothers did) *Sansterre* or Lackland, under the influence of his mother Eleanor, had been nominated by Richard I. his successor to the throne. In this the English acquiesced, though it ex-

cluded from the crown his nephew, Prince Arthur (born 29th March, 1187), son of Geoffrey, duke of Brittany, and violated the law of primogenitnre. Against this Philip II.—anxious by a quarrel to regain, if possible, the French provinces held by the kings of England—declaimed, and by the wars resulting from his espousal of Arthur's title, gained in the end most of the French fiefs.

John was accepted as Duke of Normandy, 25th April, 1199, and recognized as King of England at the Council of Northampton. He landed at Shoreham 25th May, was crowned on Ascension Day, and shortly thereafter returned to Normandy, owing to Anjou, Maine, and Touraine having declared in favour of Arthur. Philip had seized Evreux, and Constance of Brittany had placed her son Arthur in Philip's keeping. John retaliated by besieging Le Mans. A two months' truce was agreed to, which John employed in making a progress through England. Arthur did homage for his continental possessions, and Philip became the prince's champion. A short war ensued. This was followed by a truce and then a peace, in which Arthur's cause was basely abandoned. John recognized as the rightful successor to Richard, Philip's son Louis received as a gift on his marriage with John's niece, Blanche of Castile, not only Evreux, but all the lands that had been taken by Philip during the war, and Arthur was ordered to do homage to John for Brittany. John divorced his wife Hadwisa, heiress of Robert of Gloucester, on the plea of consanguinity, and married Isabella of Angoulême. Both were crowned at Westminster, 8th October, 1200. Hugh Lusignan, count de la Marche, who had been betrothed to Isabella, excited a rebellion against John in Poitou. Philip summoned John to answer the charges of the Poitevins. John disregarded the mandate. Arthur and Hugh besieged Eleanor in the castle of Mirabeau. John relieving her, defeated and captured them. Arthur was sent first to Falaise, afterwards to Rouen, and there in some mysterious way came to an untimely end, 3rd April, 1203. Arthur's sister, "the pearl of Brittany," was made a life-long prisoner in Corfe and in Bristol. Hugh de la Marche was long confined in chains at Caen.

On the complaint of the Bishop of Rennes, Philip summoned John to answer to him for the murder of a kinsman and a vassal. John treated the citation with contempt. Philip proclaimed him a traitor and a felon, and adjudged him to have forfeited all his fiefs in France, and took military possession. John, boasting that he could recover in one day all he had lost, remained idle at Rouen, and calmly returned to England in December. After a half-hearted, ill-supported, and readily abandoned attempt to organize a resistance, John made a two years' truce with Philip. Eleanor died 1st April, 1204, and after that John seems to have let his possessions slip out of his grasp. All except Guienne were lost by 1206.



Rouen.

In the meantime difficulties thickened around him in England. Hubert, archbishop of Canterbury, died 13th July, 1205. The monks chose their sub-prior Reginald; the king appointed John de Grey of Norwich to the archiepiscopal seat. Innocent III. set both aside, and assigned the office to his friend and fellow-student, Stephen Langton, a cardinal and an Englishman, whom he consecrated to the archbishopric at Viterbo, 27th June, 1207. John resisted this papal encroachment. He, full of passion and fury, raged against Innocent, drove the monks of Canterbury out of the country, and seized their possessions. The pontiff, calmly inflexible, and knowing too that John was unpopular because he had seized a thirteenth part of all property, secular and ecclesiastical, threatened an interdict. Though John averred that he would slit the noses and pluck out the eyes of all the clergy in his dominions, and send them to the Pope, if any Italian priest should interfere with him or his people, the papal interdict was read in London, 23rd March, 1208, by the Bishops of Ely, Worcester, and London, who immediately escaped to the Continent. The churches were closed, and—except to baptize infants and to administer the sacrament to the dying—all ecclesiastical functions ceased. John commanded the extradition of all the clergy who obeyed the interdict, claimed new oaths of fealty from his subjects, and enforced bonds and hostages for submission from his barons. Many of the latter fled to Ireland and Scotland. Innocent, finding John ob-

durate, excommunicated him by name (November, 1209); absolved his subjects from their fealty in 1211, and after having sent Durand, a knight-hospitaller, and Cardinal Pandulph on a mission of reconciliation between John and the church, which failed in getting any concession or submission from the king, proceeded to depose him, and enjoined Philip to dispossess him of his dominions. Philip eagerly enough undertook the pious task, and assembled a large army at the mouth of the Seine, April, 1213. After having captured one of Philip's squadrons, destroyed the vessels in the harbour of Fécamp, and burnt Dieppe, John lost courage, invited Pandulph to an interview, and surrendered through him his kingdom to the Pope as lord paramount. England, as a part of the patrimony of St. Peter, was now sacred soil, and Philip was ordered to disband his forces. He turned his wrath against Flanders, which was in compact with John. The French fleet was attacked by the English navy at Damme, and Philip was defeated. At Dover, 13th May, 1213, Pandulph received John's homage to the Pope for his dominions; the papal excommunication was revoked 28th July, and the interdict was removed 6th December. John had been astir politically during the ecclesiastical paralysis. He had marched to Berwick and compelled homage from Scotland's king; extorted large sums from the Jews, and inflicted heavy penalties on the church. In 1210 he had gone to Ireland and subdued the settlers; invaded Wales and ravaged it. His cruelty and rapine alienated many of the barons, and though they escaped the king seized their estates. Caprice and tyranny, cupidity and abjectness, excited hatred and contempt. It was resolved to assert the rights of the country against the rapacity of the crown. When John, bent on revenging Philip's duplicity and regaining his prestige and possessions, prepared to invade France, the barons refused to accompany him. Landing near Rochelle, 15th February, 1214, John in July was repulsed before Roche aux Moines, and his forces, along with his Flemish auxiliaries, were defeated by Philip at Bouvins. John having treated for a truce, returned to England in October to find his nobles banded together to demand a redress of grievances. At their head was Stephen Langton. They met at St. Edmondsbury, 25th November; drew up and presented their demands at London, 6th January, 1215. The king asked delay till Easter, tried by favour and intimidation to break up the confederacy, and appealed to the Pope, who censured Langton and the barons. They assembled at Stamford, John temporized, and they entered London, 24th May. At last John agreed to meet them on the "Meadow of Council," Runnymede, near Egham, on the Thames; did so, had *magna carta* presented to him, and conceded it. In this document the main points of a constitution determining duly in some measure the rights and duties of subject and sovereign were first formulated and set forth in "black and white." It secured the full rights and liberties of the church, the settlement and limitation of the feudal relations of superior and vassal, the right of the nation to revise taxation, the proper regulation of official appointments, the milder treatment of debtors, trial by peers; that justice should neither be sold, put off, nor denied; freedom of ingress and egress in times of peace, the dismissal of mercenaries, an inquiry into the forest laws; that the peasantry by no fine should be deprived of their carts, ploughs, and implements of husbandry; and the immunity of Llewellyn of Wales and Alexander of Scotland from suffering for the help they had given.

John seems never to have intended to abide by the charter to which he had set his royal seal. His rage was fierce. He hired mercenaries anywhere, seized and sacked Rochester, rushed—plundering, wasting, and burning on his way—to drive the "red-fox Alexander" from his Northumbrian possessions. The Midlands were harried by fire and sword used by foreign troops. These slew the poor, tortured the rich, and proved plunderers everywhere. The barons offered the English crown to Louis of France, who landed at Stour, was welcomed at London, and had homage done to him. John, leaving the Poitevin, Hubert de Burgh, to keep Dover Castle, made for the west, got help from the Welsh borders, marched across the Midlands to Lincoln and Lynn, which he took, and turned his thoughts to the levelling of London. On the way through the Wash, his baggage and treasure were by some mischance swallowed in a quicksand, 11th October. Having narrowly escaped from immersion, John reached Swineshead Abbey, where he put up for the night. Next day, whether from anxiety, poison, or passion, he was seriously ill. He would not rest, but hastened on to Newark, where, after feasting on peaches and new cider, a violent fever developed. There, after bequeathing his soul to God and his body to St. Wulfstan, he died 19th October, 1216. He was buried in Worcester Minster, as he had wished. John was stalwart, handsome, and well mannered, fair of speech and highly talented, but cruel, cold-hearted, ungrateful, and selfish; faithless alike to promise or bond, full of pride and passion, yet cowardly and superstitious. Despite his consummate power of managing men, he was humbled by the rival he hated, the Pope he scorned, and the subjects he betrayed, and lost an empire through reckless self-will.

THE GREEK LANGUAGE.—CHAPTER VI.

THE CONJUGATIONS IN μι—EXERCISES IN READING.

The investigations of philologers appear to have conclusively proved that the conjugation in μι, though it is now arranged by grammarians as the second main division of verbs, was really the original form of conjugation employed by the early speakers of the Greek language. It is historically the *ancient* as distinguished from the *modern* form of conjugation, and though, like the strong verbs in German and English, which are often regarded as irregular, the verbs classified under it have in process of time become few in comparison with those which exhibit their differences of mood and tense according to the modern or weak forms—they having fallen, as it were, into a secondary position—they really preserve for us the primitive forms of inflexional change. Most probably, as Dr. J. W. Donaldson says, "all verbs originally agreed in their person-endings with those in μι. . . . Those which are still so conjugated express the most elementary notions, and therefore must be considered as the oldest verbs. . . . Greek verbs in μι are distinguished from the other verbs (in ω) by certain peculiarities." According to these peculiarities they should be classed. Verbs in μι of the first class affix their terminal inflexions *directly* (*i.e.* without a connecting vowel) to the stem, as φημι, I say. Those of the second class insert the syllable νυ in the pure stem to form the present stem; as, pure stem ῥαγ, present stem ῥαγνυμι, I tear. Those having stems ending in a vowel strengthen the present stem by doubling the ν; as, pure stem σβε, present stem σβέννυμι, I quench.

The number of verbs in this conjugation is comparatively small. The only tenses that are peculiar to them are the present and imperfect in all the voices, and in a few of them the second aorist active and middle, which is formed in both voices by eliding the reduplication; as ἔ[τι]θην, ἔ[δι]δων, ἐ[τι]θεμην, ἐ[δι]δομην.

Of the *two* classes of verbs in μι, the characteristic stem of the *first* is α, ε, or ο, and that of the *second* is υ.

Class I. *Reduplicatives.*—The stems of verbs which require this mode of conjugation end in one of the vowels, α, ε, or ο. A reduplication consisting of the initial consonant of the stem, with ι, is prefixed to the present and imperfect. Thus the stem δο-, I give, is lengthened into δω-, which, with the first person-ending -μι, makes δω-μι, and this again, with the reduplication, δι-δω-μι. So θε-, lengthened into θη, becomes, with first person-ending, θη-μι, and with the reduplication, τι-θη-μι. Should the stem, however, begin with σ, or an aspirated vowel, the reduplication of the σ is not made, but an ι aspirated alone is prefixed; thus the stem στα-, being lengthened into στη-, with the person-ending becomes στη-μι, and with the aspirated ἱ of the reduplication ἱ-στη-μι. Three of these verbs, τιθημι, I place, διδωμι, I give, and ἱημι, I send, have the inflexion -κα, instead of -σα, in the first aorist indicative active; as, ἔθηκα, ἔδωκα, ἧκα. But the use of this form is almost wholly confined to the singular number.

Class II. *Insertives.*—In this class νυ or ννυ are added to the stem prior to the addition of μι, and no reduplication of stem takes place; as, stem δεικ, giving with addition of νυ and the first person-ending μι, δείκ[νυ]μι, I extend the right

hand, I show. Similarly ἐν[νυ]μι, I dress, σκεδά[ννυ]μι, I scatter, ζευγ[νυ]μι, I join, πηγ[νυ]μι, I fasten, &c., may be analyzed.

Following the arrangement of the tabular form given of verbs in ω (p. 576), we supply hereunder classified examples of the principal parts of verbs in μι.

Characteristic.		Present.		Stem.	Future Active.	Perfect Active.	Future Passive.	Perfect Passive.
Class I.,	α	ἵστημι,	I set	στα	στησω	ἕστηκα	σταθησομαι	ἕσταμαι
	ε	τιθημι,	I put	θε	θησω	τεθεικα	τεθησομαι	(τεθειμαι)
	ω	διδωμι,	I give	δο	δωσω	δεδωκα	δοθησομαι	δεδομαι
Class II.,	υ	δεικνυμι,	I show	δεικ	δειξω	δεδειχα	δειχθησομαι	δεδειγμαι

Exercise.—If the student will now read carefully over the examples of the classes of verbs in the two conjugations, and (1) notice the changes made in each part, (2) imitate the changes made in each of these in their respective classes, while writing out in a similar tabular form the following verbs, he will soon acquire a fair mastery over the chief changes made in the course of the conjugation of verbs. We supply the three main tenses of the active voice, in the first place taking verbs in ω.

Class I.

Present.	Future.	Perfect.	
βλεπω,	βλεψω,	βεβλεφα,	to see.
δρεπω,	δρεψω,	δεδρεφα,	to pluck, reap.
λειπω,	λειψω,	λελειφα,	to leave.
ἀμειβω,	ἀμειψω,	ἤμειφα,	to change.
ἀλειφω,	ἀλειψω,	ἤλειφα,	to anoint.
στεφω,	στεψω,	ἐστεφα,	to crown.
ἁπτω,	ἁψω,	ἧφα,	to fasten, kindle.
βαπτω,	βαψω,	βεβαφα,	to dip.
βλαπτω,	βλαψω,	βεβλαφα,	to see.
δαπτω,	δαψω,	δεδαφα,	to devour.

Class II.

βρυκω,	βρυξω,	βεβρυχα,	to gnaw.
διδασκω,	διδαξω,	δεδιδαχα,	to teach.
διωκω,	διωξω,	δεδιωχα,	to pursue.
θηγω,	θηξω,	τεθηχα,	to sharpen.
ληγω,	ληξω,	λεληχα,	to leave off.
ἀγχω,	ἀγξω,	ἦγχα,	to strangle.
ἀρχω,	ἀρξω,	ἦρχα,	to rule.
βρεχω,	βρεξω,	βεβρεχα,	to moisten.
ἐλεγχω,	ἐλεγξω,	ἤλεγχα,	to confute.
ταρασσω,	ταραξω,	τεταραχα,	to disturb.

Class III.

ᾄδω,	ᾄσω,	ᾖκα,	to sing.
πληθω,	πλησω,	πεπληκα,	to fill.
βαζω,	βαξω,	βεβαχα,	to speak.
βλιττω,	βλισω,	βιβλικα,	to squeeze out.
πλαττω,	πλασω,	πεπλακα,	to form.
ψαλλω,	ψαλω,	ἔψαλκα,	to play an instrument.
φαινω,	φανω,	πεφαγκα,	to show.
περθω,	περσω,	πεπερκα,	to ravage.
φροντιζω,	φροντισω,	πεφροντικα,	to think.

Class IV.

ἀγαλλω,	ἀγαλω,	ἤγαλκα,	to exult.
θαλλω,	θαλω,	τεθαλκα,	to flourish.
αγειρω,	αγερω,	ηγερκα,	to gather.
ἀγγελλω,	ἀγγελω,	ἤγγελκα,	to bear tidings.
ἀγειρω,	ἀγερω,	ἤγερκα,	to congregate.
ἀιρω,	ἀρω,	ἦρκα,	to lift up.
βαλλω,	βαλω,	βεβληκα,	to throw.
δεμω,	δεμω,	δεδμηκα,	to build.
καμνω,	καμω,	κεκμηκα,	to labour.
κειρω,	κερω,	κεκαρκα,	to shave, shear.
κτεινω,	κτενω	ἔκτακα,	to kill.

Class V.

σειω,	σεισω,	σεσεικα,	to shake.
παιω,	παισω,	πεπαικα,	to strike.
βοαω,	βοησω,	βεβοηκα	to cry out.
αἰνεω,	αἰνεσω,	ἤνεκα,	to praise.
ξεω,	ξεσω,	—	to shave.
νικαω,	νικεσω,	—	to conquer.
δηλοω,	δηλωσω,	—	to show.
δακρυω,	δακρυσω,	—	to weep.
φυω,	φυσω,	—	to beget.
ἐαω,	ἐασω,	—	to suffer.
μειδιαω,	μειδιασω,	—	to smile.
πειραω,	πειρασω,	—	to tempt.

Class VI.

ἀγαπαω,	—	—	to love.
γελαω,	—	—	to laugh.
ἐρευναω,	—	—	to investigate.
αιτεω,	—	—	to ask.
δονεω,	—	—	to agitate.
κινεω,	—	—	to move.
μορφοω,	—	—	to shape.
χρυσοω,	—	—	to gild.

Of the conjugation in μι, the following are examples, to be arranged like those given in the foregoing table.

Class I.

ἵπτημι,	—	—	to fly.
ἴσημι,	—	—	to know.
ὄνημι,	—	—	to benefit.
τεθνημι,	—	—	to die.
τλημι,	—	—	to bear.

Class II.

ἀγνυμι,	ἄξω,	ἦχα,	to break.
ζωννυμι,	ζασω,	ἔζακα,	to gird.
οἰγνυμι,	οἰξω,	ὦξα,	to open.
ὀμοξγνυμι,	ὀμοζξα,	ὠμορχα,	to wipe off.
ὀρεγνυμι,	ορεχω,	ορεχα,	to stretch.

Easy Readings in Greek.

The following specimens of simple sentences selected from the Gospels will form an exercise in the reading of Greek, and will afford opportunity for parsing nouns, adjectives, and verbs. This may readily be done by consulting the inflexional forms in the respective paradigms, and finding the part with which the several words agree.

1. Ἐγω εἰμι,	I am, It is I.
2. Ἐγω ἀνθροπος εἰμι,	I am a man.
3. Ουκ εἰμι ἱκανος,	I am not worthy.
4. Θελω,	I will.
5. Ἀμην λεγω ὑμιν,	Verily, I say unto you.
6. Ἐγω ἀποστελλω ὑμας,	I send you.
7. Λεγει αὐτοις,	He saith unto them.
8. Οὑτος βλασφημει,	This (man) blasphemeth.
9. Πραος εἰμι και ταπεινος τῃ καρδια,	I am meek and lowly in heart.
10. Ὁ ἀγρος ἐστιν ὁ κοσμος,	The field is the world.
11. Οὑτος ἐστιν ὁ υἱος Δαβιδ,	This is the son of David.
12. Οὑτος ἐστιν ὁ του τεκτονος υἱος,	This is the son of the carpenter.
13. Ὑμεις ἐστε το αλας της γης,	Ye are the salt of the earth.
14. Ὑμεις ἐστε το φως του κοσμου,	Ye are the light of the world.
15. Εἰς το οὐς ακουετε,	Ye hear in the ear.
16. Ἐγω εἰμι ἡ θυρα,	I am the door.
17. Ἐγω εἰμι ο ποιμην ὁ καλος,	I am the good shepherd.
18. Υἱος του Θεου εἰμι,	I am the Son of God.
19. Λεγει αυτῳ Σιμων Πετρος,	Simon Peter saith unto him.
20. Ἐγω εἰμι ἡ ὁδος, και ἡ ἀληθεια, και ἡ ζωη,	I am the way, the truth, and the life.
21. Ἐγω εἰμι ἡ ἀμπελος ἡ ἀληθινη,	I am the true vine.
22. Ἐγω εἰμι ἡ ἀμπελος, ὑμεις τα κληματα,	I am the vine, ye are the branches.

ENGLISH LITERATURE.—CHAPTER VIII.

SHAKSPEARE AND HIS CONTEMPORARIES: MUNDAY—DANIEL —LORD BROOKE—CHAPMAN—MARLOWE—CHETTLE—CYRIL TOURNEUR, &c.

Players and playwrights were at first, of course, of a rather motley and nondescript character, and—the drama not being recognized as a career—a good many waifs and strays from all kinds of professions and places gravitated towards the stage. In these early times actors were unembodied, unorganized, and had no fixed or ordinary "local habitation" for the exercise of their quality. The Earl of Leicester, in May, 1574, made the earliest effort to form them into a respectable professional fraternity, by securing what we would now call a "dramatic patent" for his players. His example was followed by many other noblemen, and numerous companies made circuit through the country. Lord Leicester's men were afterwards incorporated with the Earl of Warwick's and Sir Robert Lane's companies, and attached to the court as her Majesty's servants, 1583. This is recorded in John Stowe's *Chronicle*, 1615, thus:—"Comedians and stage-players of former times were very poor and ignorant in respect of those of this time; but being now [anno 1583] growne very skilful and exquisite actors for all matters, they were entertained into the service of divers great lords, out of which companies there were twelve of the best chosen, and, at the request of Sir Francis Walsingham, they were sworne the queene's servants, and were allowed wages and liveries as groomes of the chamber; and until this year, 1583, the queen had no players."

The aim after professional recognition, and the desire to avail themselves of the profits likely to accrue from the popularity of stage-plays, led also to the erection of special buildings for the purpose, and both the *Curtain* and the *Theater* were built, in 1576, as public places for the performance of plays. The queen's company occupied The Red Bull. Newington Butts was built 1580. The Rose and Hope was opened in 1585, the Swan in 1595, Blackfriars in 1596, the Globe in 1599, the Fortune in 1600, and so on. London, in fact, at the close of the reign of Elizabeth had no fewer than eleven theatres. On 24th July, 1579, Edmund Tylney was made Master of the Revels, and after that greater attention than formerly was given to theatrical productions. These and many other indications of the decided hold the drama had then taken of the public taste, and the gradual acceptance of stage-plays as a part of the popular amusements of the time, afford perhaps sufficient reason why a number of "university pens" about this time, under the impression that they were "well able to bumbast out a blancke verse," betook themselves to the stage, if not exactly as a professional pursuit, yet as a makeshift—often ending in its being the only shift they could make till death overtook them. The volume, value, and variety of the work produced by these pioneers of the dramatic art are extraordinary. Although in their mass there be few flawless masterpieces, there is a grand rude monumental originality, and often an enthralling fascination in their exhibitions of the marvel and the mystery possible in human life. Of some of the more remarkable mention must be made, though it will be impossible to name all, or to quote from the works of any except those which are not readily procurable by the general reader.

Anthony Munday, a popular pamphleteer, translator, and playwright, was born in 1553. His contributions to the stage extend from 1580 to 1621. He was apprenticed to John Allde, printer, London, but became an actor. In some way he reached Rome and was taken into the seminary. He came into notoriety by being a witness against the Jesuits, and was the writer of "A Briefe Discourse of the Taking of Edmund Campion"—"an elegant orator, a subtle philosopher and disputant, an exact preacher in English or Latin tongue, of a sweet disposition, and a well-polished man," as Anthony Wood says—who was executed at Tyburn as an adherent of the Bishop of Rome, 1st December, 1581. Munday had previously written the "Mirror of Mutability" (1579), a series of verses mainly founded on Scripture, and having the form of "Complaints," and in 1580 "The Fountaine of Fame" and "The Paine of Pleasure," "profitable to be perused by the wise, and necessary to be by the wanton." He was one of the Earl of Oxford's players, and issued "A View of Sundrie Examples," an undigested heap of notes on murders, crimes, wonders he had heard of abroad or seen at home, including the earthquake in April. The plot of the play "A Warning to Faire Women" (1599), was founded on an incident related in this book. His rhyming tragedy, "Fidele and Fortunatus" (which Langbaine mentions), was entered on the Stationers' Registers in 1584. He had by 1598 acquired a reputation, which Meres notes, as "the best plotter," and which Ben Jonson ridicules in "The Case is Altered" (1609), by bringing him on the stage as Antonio Balladino, "the pageant poet of the city," and "in print already for the best plotter." By this time he had been one of the messengers of her Majesty's [Elizabeth's] chamber and become a "citizen and draper," and contributor of what Webbe calls "very rare poetrie" to the showy entertainments of the city guilds, some of which appear in his "Metropolis Coronata." He translated from the French "The Paladin" and "The Palmerin of England," the latter a favourite book with Leigh Hunt and Keats. Of the numerous dramas which he, in association with Henry Chettle, Robert Wilson, Michael Drayton, Richard Hathwaye, Thomas Dekkar, and others of Henslowe's stage-play purveyors, produced, few have been preserved in type. "John-a-Kent and John-a-Comber," a lively comedy, lay in MS. (imperfect) from 1595 till edited in 1851 by J. P. Collier. "The Downfall of Robert, Earl of Huntingdon" [Robin Hood], and its sequel, "The Death of Robert, Earl of Huntingdon," in which he was assisted by Chettle, contain effective passages, vigour and spirit often animate them, though they are carelessly constructed and hastily composed. In it we find a similarity of expression which becomes explanatory of Shakspeare's line—

> "The multitudinous seas incarnadine."
> —"*Macbeth*," II. ii. 62.
> The multitudes of seas dyed red with blood.

Munday died 10th August, 1633, aged eighty, and was buried in the Church of St. Stephen's, Coleman Street.

Samuel Daniel, whose father was a musician, was born near Taunton, in Somersetshire, 1562. He was a student at Magdalen Hall, Oxford (1579–86), but left without a degree, though prior to this he had translated "The Discourse of Rare Inventions" of Paolo Giovio (Paul Jovius). Having become tutor to the celebrated Anne Clifford, daughter of George, earl of Cumberland, and subsequently Countess of Pembroke, he was patronized by that noble family. In a large-gardened house in Old Street, St. Luke's, London, he diligently pursued, in a quiet pensive way, the arts of authorship as poet, historian, and dramatist, and lived on terms of intimacy with the most celebrated of the literary men of his time. He earned fairly the epithet of the "well-languaged Daniel." In 1591 Thomas Nashe surreptitiously issued twenty-eight poems by Daniel among the additions to the first edition of Sir Philip Sidney's "Astrophel and Stella" (1591). Of them the author reclaimed twenty, when he published, in 1592, apparently in three different editions, his "Delia," sweet-tuned sonnets to his lady-love, who dwelt, he says, on the banks of the "Avon, rich in fame, tho' poore in waters." This book contains also "The Complaint of Rosamond." They were both augmented in 1594, and were highly popular and frequently reprinted, with alterations. In the same year he published, as a companion to the well-graced "Antonie," which Mary, countess of Pembroke, had, in 1590, done into English from the French of Garnier, his "Tragedy of Cleopatra," a much esteemed drama in its day, after the model of Seneca, simple in plot and incident, careful of the unities, and more sedulous of exciting moral than romantic interest. Next year, driven by necessity to the use of his pen, he issued "certaine small workes," among which was "The Tragedy of Philotas," a favourite often reprinted, though it brought upon its author the charge of defending the Earl of Essex, sympathy with whose treason he disavowed, yet acknowledged that he was "particularly beholden to his bounty." For an entertainment presented by the University of Oxford in Christ Church, to Queen Anne and her ladies, on the occasion of a royal visit in 1605, Daniel produced "a

pastoral tragi-comedie," entitled "The Queen's Arcadia," printed in 1606. He held the appointments of master of the revels, gentleman extraordinary, and groom of the chambers to the queen. Besides these plays he composed and issued fragmentarily a heroic poem, "The Civil Wars between the Houses of Lancaster and Yorke," in eight books, graceful in language, sweet in thought, though wanting in passion, fire, and versatility, and a "History of England" in prose; besides a general defence of learning, in irregular terza-rima, dedicated to Fulke Greville, entitled "Musophilus"—his masterpiece in poetic art—many epistles, odes, masques, minor poems, and miscellaneous verses. In his later days, regretfully feeling that he had outlasted his reputation, and that, in his own words,

> "Years hath done this wrong,
> To make me write too much and live too long,"

he retired to Ridge, a hamlet in the parish of Beckington, in Somersetshire, and there—some time after 4th September, 1619, on which day, "sick in body, but well in mind," he made his will—died. In the parish church Anne, countess of Pembroke, Dorset, and Montgomery, erected a monument to the "religious and honest poet," who had been her tutor. John Daniel, his brother, with approval of the poet's brother-in-law, John Phillipps, issued from the press of his "loving friend, Mr. Simon Waterson," in a very handsome volume, the poet's whole works in poetry (1623), and verses were dedicated to his memory by many who had taxed "the utmost powers of English rhyme."

The Sir Fulke Greville to whom Daniel appropriately dedicated his "Musophilus," was the son of Sir Fulke Greville and his wife Anne Neville, daughter of Ralph, earl of Westmoreland, and was born at the family seat, Beauchamp Court, in the parish of Alcester, Warwickshire, in 1554. In November, 1564, Sir Philip Sidney and he were entered together as pupils of the grammar school at Shrewsbury, and the latter matriculated as a student of Jesus College, Cambridge, 28th May, 1568. Having made the grand tour, he was introduced to the court, and gained the favour of Queen Elizabeth, who knighted him. Sir Henry Sidney, lord president of Wales, engaged Greville in his office. Ultimately he became clerk to the signet in Wales, 1581, and in 1583 was constituted secretary of the entire principality. He was, along with Sir Thomas Lucy of Charlecote, member of Parliament for Warwickshire during six parliaments. By his constituents at Stratford-upon-Avon he was highly popular, and was frequently entertained by the corporation and the townspeople. He was a patron of learning and the arts. The master spirits of the time found in him a friend, and Beauchamp Court was quite a resort of thinkers and poets as well as politicians. By Greville and Sir Philip Sidney Giordano Bruno was welcomed friendlily when he fled from the persecution of the church, and by their aid he published many of his works. During Bruno's visits to Beauchamp Court (1583–85) may not William, the son of Mr. John Shakspeare, high bailiff of Stratford, known to be "naturally inclined to poetry and acting," a handsome young man of notable talent, have been invited to meet Daniel, Drayton, John Florio, Dyer, Harvey, the author of the "Arcadia," and the exile for freedom of faith—poet, philosopher, and dramatist, and felt in Alcester some of the intellectual quickening which, seemingly received from Bruno, gives weight of thought to "Hamlet" and airy grace to "Love's Labour's Lost?"

Not long after Sidney's death, which took place at Zutphen, Greville was appointed treasurer of the navy and chancellor of the exchequer. Meanwhile, under the influence of some unchronicled romance, wherein love ran an unsmooth course, Greville betook himself to "sonneting"—in the sense of writing short poems having the passion of love as their theme. These poems appeared in 1633, among "certaine learned and elegant works," written in his youth, with the simple heading "Cælica" [=heavenly one?] They are full of the stuff of thought, not merely "a painted skinne" of many words. All Greville's poetry is "thought-bound." He evidently wrote under the conviction that

> "Those words in every tongue are best
> Which do most properly expresse the thought,
> For, as of pictures, which should manifest
> The life, we say not—that is fineliest wrought
> Which fairest simply shows, but faire and like:
> So words must sparkes be of those fires they strike."

The same volume contained "A Treatise on Humane Learning"—full of wise aphorisms tersely stated; "An Enquisition upon Fame and Honour," which he regards as

> "Like voice and echo—joined, yet divers things."

"A Treatise of Warres," quite a warfare of words against war, rich in thought, coined into proverbial currency, *e.g.*—

> "Care is sold deare, and sloth is never cheap.
> Men would be tyrants, tyrants would be gods.
> States have degrees, as humane bodies have,
> Spring, summer, autumn, winter—and the grave.
> Art prunes the earth, confusion leaves it waste.
> The more remote from God the less remorse."

Next come the two tragedies, "Alaham" and "Mustapha," two poem-plays, or rather philosophical dialogues with choruses interspersed, not written for the stage, but to present his thoughts to those "that are weather-beaten on the seas of this world," "as directing threads, to guide every man through the confused labyrinth of his own desires and life." In them, as in all his poems, there is observable, as Park says, "a close, mysterious, and sententious way of writing, but without much regard to elegancy of style or smoothness of verses." He also wrote a tragedy on "Antony and Cleopatra," "according to their irregular passions, in forsaking empire to follow sensuality," but this the author sacrificed in the fire after Shakspeare's great play appeared. His own favourite productions seem to have been a series of philosophico-poetical treatises on "Monarchy," with an appended "Treatise on Religion," remarkable for its splendid spiritual metaphysic—both containing thoughts of great worth much compressed, not artistically expressed.

By James I. he was raised to the peerage in 1620 as Lord Brooke of Beauchamp Court; in 1628, after having been councillor to Charles I. for three years, he was assassinated by his man-servant, Ralph Heywood, who immediately committed suicide. Stabbed mortally in the back with a knife in his bed-chamber at Brooke House, Holborn, London, on 1st September, he lingered on till the 30th, when he died, aged seventy-four, and was buried in the chapter-house of St. Mary's, Warwick, in his own vault, under a monument occupying the whole interior of the apartment, erected in his own lifetime, bearing this inscription: "Fulke Greville, servant to Queen Elizabeth, councillor to King James, and friend to Sir Philip Sidney. *Trophæum Peccati* (*i.e.* a memorial [of 'the wages] of sin'—Death)."

George Chapman, who, as Dr. Warton says, "contributed in no inconsiderable degree to enrich and advance the English stage," was born at Hitchin, Herts, 1557, and educated both at Cambridge and Oxford. He was an excellent scholar. William Browne in "Britannia's Pastorals" speaks of him as "the learned shepherd of fair Hitchin-hill." His earliest poem, "Skianuktos," appeared in 1594, and in 1595 his translation of Ovid's "Banquet of Sense." The beautiful episode of "The Shield of Achilles," from Iliad xviii. 590, &c., first gave note in 1596 of a Homeric translator of unequalled scholarship and poetical skill in that age. He contributed to the stage his first play, "The Blind Beggar of Alexandria," 12th February, 1595–96. It was printed in 1598. "A Humourous Day's Mirth" came out in 1599. "All Fools" belongs to 1605, in which year, along with Ben Jonson and John Marston, he wrote "Eastward Hoe," for some passages in which, offensive to the Scotch, he and Marston were imprisoned, and Ben Jonson voluntarily shared their danger; but they were soon released, and in a merry feast with Camden, Selden, and others, celebrated their deliverance. "The Gentleman Usher" and "Monsieur d'Olive" were produced in 1606. Both met with success, and he again tempted censure in 1607 by a play on Bussy d'Ambois, a soldier of fortune in the days of Henry III. In 1608 he produced, while their hero was yet alive, "The Conspiracy" and "The Tragedy of Charles, Duke of Byron," field-marshal

of France under Henry IV. The French ambassador objected to certain parts of these two plays as they were first acted, and they were altered. He issued, in 1611, his witty comedy of "May Day;" in 1612, "The Widow's Tears," and in 1613, "The Revenge of Bussy d'Ambois;" and then seems to have withdrawn from the writing of stage plays. During a few years about this time he [probably] held the office of one of the household chaplains, who attended monthly, two by two, on Prince Henry, on whose "most disastrous death" (6th November, 1612) he issued an "Epicede or Funeral Song," and in 1613 "The Funerals of the High and Mighty Prince Henry of Wales."

Chapman regarded the stage not as the direct organ of "truth, but things like truth." To show that this was the inner essence of poetry he presented the English with a version of

"Homer, lasting, living, reigning,
And proves how firm truth builds in poet's feigning."

"The full and heightened style of Master Chapman," as Webster phrases it, is nowhere more observable than in his transfusions of the mind of Homer into English words. Of his predecessors in the endeavour to present the wondrous works of the blind old Scian bard in any other language than the living Greek, he finely says,

"They failed to search his deep and treasurous heart.
The cause was this: they wanted the fit-key
Of nature, in their downright strength of art,
With poesy to open poesy."

Chapman completed Marlowe's "Hero and Leander," as Chettle says, "with graces as great and words and verses as fit." He also translated Musæus, 1616, and Hesiod, 1619. In 1631 his play of "Cæsar and Pompey," written long previously and never given to the stage, was printed. Its aim was to show that "only a just man is a freeman." A play licensed in 1632, but not published till 1639, entitled "The Ball," was then issued as a joint production of George Chapman and James Shirley, and a like double authorship is assigned to "Chabot, Admiral of France," though A. C. Swinburne sees as little trace of Shirley's hand in the latter as of Chapman's in the former. This poet was reverent in aspect, religious in his frame of mind, temperate in habits, choice in his company, and estimable in his private character. He lived to an advanced age. He died in 1634, and Inigo Jones planned and erected a monument over his burial-place in St. Giles'-in-the-Fields, London. Here are one or two poetic pearls from his caskets—

"There is One
That wakes above, whose eyes no sleep can bind:
He sees through doors and darkness all our thoughts.

Man is a torch borne on the wind—a dream
But of a shadow.

Gold will not turn to dross for deepest trial.

In needful dangers ever choose the least."

Christopher Marlowe, son of John Marlowe, shoemaker, Canterbury, was baptized 26th February, 1563–64. He was educated at the King's School, and matriculated as a "pensioner," *i.e.* commoner, at St. Benedict's (Corpus Christi) College, Cambridge, 17th March, 1580–81, where he graduated B.A. 1583, M.A. 1587. How he passed the interval between these two scholastic incidents is not known. It has been supposed that he followed Leicester and Sidney to the wars in the Netherlands; but it seems certain that at an early age he was "stage-struck." He "rose from an actor to be a maker of plays," and became a literary adventurer in the metropolis—urged thereto, probably, by the fact that having adopted atheistical opinions from his fellow-student, Francis Kett (burnt as a heretic at Norwich, 1587), a career in the learned professions was closed to him. The demand for plays made dramatic authorship a ready outlet for talent and a means of attaining an income. He became the idol of the town and the envy of his fellows by the production of "Tamburlaine" (1587). He had probably exercised his baccalaureate brains in a rhymed line for line version of Ovid's "Amores," which, despite the lively and alluring delicacy of its measures, owing to the objectionableness of its matter, was, when published after his death, burned by the common hangman; in his translation of Lucan's "Pharsalia" (Book I.), which indicates his apprentice efforts in happily-chosen blank verse, and (perhaps) in the classical drama, "Dido," left unfinished and completed by Nash. These tentative prelusions were followed by a finely designed poem, "Hero and Leander," of which rather more than two sestiads were issued in 1590, edited by Edward Blunt, and dedicated to Sir Thomas Walsingham, Knt., as one "that in his lifetime bestowed many kind favours, with good countenance and liberal affection, upon the unhappily deceased author." It is a piece of exquisite work, well conceived, excellently executed. In "Tamburlaine the Great"—full, as Ben Jonson remarks, of "scenical, startling, and furious vociferation" though it is —Marlowe proved himself "the Muses' darling." He

"Had in him those brave translunary things
That the first poets had."

The elasticity, variety, and free-footedness of the verse, the poetic inspiration and passionate exaggeration of the matter, and the tameless scornfulness of this melodramatic tragedy stormed the stage. He strode like a well-thewed Hercules into the public view, and claimed the plaudits of the playgoers. To their rapturous "encore" he resumed the task of showing, in a second part, "the Scythian Shepherd," in his energetic ranting figurative style, "threatening the world with high astounding terms," as the scourge of God. The strained decasyllabic diction, which he had doubtlessly adopted as an effective makeweight for the ring of rhyme, he modified in his next play, the plot of which, with his usual delight in dallying with "unlawful things," he took from the legendary marvels of necromancy and magic. "The Tragical History of Dr. Faustus," founded on a famous *Faustbuch*, published by Johann Spies (1587), was probably first produced in 1588. In the prologue, Marlowe jests at Divinity as "the fruitful plot of scholarism graced;" and in "Perimedes the Blacksmith," Greene, after alluding to "Atheist Tamburlaine," speaks of "mad and scoffing poets, bred of Merlin's race, that set the ends of *scollarisme* in an English blank verse." Some four years after, Greene, when he issued his "Never too Late," found his title in this play, where the good angel says, "*Never too late*, if Faustus can repent" (scene vi. 84)? Milton ("Paradise Lost," i. 252–55) saw the fine moral significance of Marlowe's "mighty line," when—in reply to the question Faustus puts to Mephistophiles, how he, one of the "unhappy spirits that fell with Lucifer," is yet free to roam the earth—the spirit of temptation says,

"Why this is hell, nor am I out of it;
Think'st thou that I (who saw the face of God,
And tasted the eternal joys of heaven)
Am not tormented with ten thousand hells
In being deprived of everlasting bliss?"

The poetry is passionate, sensuous, striking, and elaborate, but—though Goethe was right in exclaiming, "How grandly is it all planned!"—full dramatic significance has not been given to the characters, the incidents, or the potent and ingenious verse. In "The Jew of Malta," Marlowe, who had dealt with the lust of power and the lust of knowledge, turns his genius to exhibit the lust of gold. The play is full of brag, blatancy, and "blood-boltered" business. It is a whirlwind of distempered life. The insatiability of gold-greed is most powerfully presented in Barabbas—especially in the early portion and the closing act. The very enthusiasm of avarice glows with a rough, new-dug, but yet a golden grace of utterance, when he exclaims:—

"Thus trolls our fortune in by land and sea,
And thus are we on every side enriched;
These are the blessings promised to the Jews,
And herein was old Abraham's happiness.
What more may heaven do for earthly man
Than thus to pour out plenty in their laps,
Ripping the bowels of the earth for them,
Making the seas their servants, and the winds
To drive their substance with successful blasts.

. . . .

They say we are a scattered nation;
I cannot tell; but we have scrambled up
More wealth by far than those that brag of faith."

These three plays, as well as "The Massacre of Paris, or The Guise"—founded on "the war of the three Henries" and the assassination of Henry of Valois at St. Cloud—are single-character pieces, and show little skill in dramatic evolution. But in his most mature work, "Edward II.," Marlowe seems to have risen to the height of a great historic ideal, and to have grasped the thought of making the past relive upon the stage. Herein he has combined pure tragic power with delicacy of treatment and variety of character. The incidents are skilfully interwoven; the dialogue, for the most part terse, vehement, boisterous, and rhetorical, is often also thrillingly passionate and pathetic. Gaveston, the Ganymede of the king's foolish favouritism, working a realm's ruin; Mortimer, the plotting paramour, who employs guilty passion in aid of political perfidy; and the unkingly king of a twice-lost kingdom—"for what are kings when regiment is gone"—and many of the other numerous characters, are excellently well discriminated. Perhaps the "unnatural false Queen Isabel" is least ably characterized. The abdication and the regicide scenes are singularly pathetic and effective. Marlowe so presents this calamitous end as if it might redeem Edward's earlier follies. And did it really form a general principle that suffering blots out sin, his own tragic death might be looked on as a purgation for his use of

> "Wit lent from heaven, but vices sent from hell."

In the last week of May, Francis Archer, a serving-man, and Marlowe, with some lewd love, had been carousing in company at Deptford. Taking offence at some (supposed) insult to his temporary *chère amie*, Marlowe drew his dagger. While it was uplifted Archer in the scuffle turned its point against its holder; it entered Marlowe's eye, pierced his brain, and, agonized by a violent death, Marlowe's short, reckless, but work-filled life closed. He was buried in the old church of St. Nicholas, 1st June, 1593, and we know not if even in his last struggle he was able to use the dying words he gave to Faustus—

> "Oh, I'll leap up to my God. Who pulls me down?
> See where Christ's blood streams in the firmament!
> One drop would save my soul! a half drop! Ah! my Christ!"

The record is silent. Out of the gloom of doom the chorus chants truly of himself—

> "Cut is the branch that might have grown full straight,
> And buried is Apollo's laurel bough
> That sometime grew within this learned man."

We have next to write the most illustrious name in the poetic literature of the world—William Shakspeare. He was born in Henley Street, Stratford-upon-Avon, 23rd April, 1564, and baptized in Holy Trinity Church on the 26th—exactly two months after Marlowe had been taken to the font. His father, John Shakspeare, a native of the neighbouring parish of Snitterfield, who had settled in the town about 1552 as a woolstapler, dealing in rother-beasts and farm produce, was then one of the chamberlains of the borough and a member of the Common Hall. He had married in 1557 Mary Arden—heiress in fee-simple of Ashbies in Wilmecote. Two daughters, Joan and Margaret, had died prior to the birth of this "son and heir"—who narrowly escaped death from the plague, and survived to be lauded by John Milton as

> "Dear son of Memory, great heir of Fame."

This boy was educated in the Free Grammar School, to a place at the desks of which he had a right (1571-77), and there, besides the "small Latin and less Greek" which Ben Jonson admitted he had acquired, he learned a great deal more than the *Sententiæ Pueriles* could ever have put into him. He was not one of those

> "Lads that thought there was no more behind,
> But such a day to-morrow as to-day,
> And to be boy eternal."
> —"*Winter's Tale*," I. ii. 63-65.

"The spirit of a youth that means to be of note begins betimes," and "fleet-winged duty with thoughts' feathers flies." We have the best evidence—his works—that he learned to use eye and mind, books and nature, and that he was therefore no inept pupil either in the lore of words or things while under Walter Roche, who became a local attorney, and by assisting whom he may have acquired his knowledge of law and legal phrases; Thomas Hunt, B.A., appointed 29th October, 1571, who subsequently became curate of Luddington; or Thomas Jenkins, to whom he may have acted as monitor, and so given occasion to Aubrey's statement that he "understood Latin pretty well, for he had been, in his younger years, a schoolmaster in the country." We know, on the same authority, that "he was a handsome, well-shaped man," "inclined naturally to poetry and acting," and "began early to make essays at dramatic poetry." His father seems to have had similar tastes. During the year of John Shakspeare's high bailiffship dramatic entertainments were first heard of in Stratford, and its guildhall, under his sanction, was graced with the performances of the Queen's and the Earl of Worcester's players. They were received with favour. The Earl of Leicester's players performed in 1573 and 1577; the Earl of Warwick's in 1576; the Earl of Worcester's in 1576, '77, '81, '82, and '84; Lord Strange's men, 1579; the Countess of Essex's players, 1579; the Earl of Derby's, 1580; Lord Bartlett's, 1581, '83; Lord Chandos', 1583; My Lord of Oxford's and the Earl of Essex's, 1584. There could have been few rural towns in England in which the poetry of the stage had equal prominence in a similar period.

John Shakspeare must have intended to educate his son as became the heir of a family of some consideration, for between 1576-79 he was in communication with the Heralds' College regarding the bearing of coat-armour as a gentleman, having been a justice of the peace, a man of good substance and ability, high bailiff of his borough, possessed of an estate of £500 per annum, and married to a member of the Arden family. Robert Cooke, Clarencieux king-at-arms, figured the "patierne" he might use as the holder of a dignity not lightly, in Elizabeth's time, to be solicited or given, and placing the bearer on the roll of England's "landed gentry." William Shakspeare may therefore have read law with Roche and studied literature with Hunt as a gentleman's son in his non-age, getting advice in the art of transforming the thoughts, emotions, and desires which thrilled within him, into the delight of succeeding ages. Early he felt the poet's inspiration, for

> "Never durst poet touch a pen to write
> Until his ink were tempered with love's sighs."
> —"*Love's Labour's Lost*," IV. iii. 346, 347.

The Shakspeares and the Hathaways had long been friendly families. William and Anne knew each other from childhood, and early began to be companions

> "That do converse and waste the time together,
> Whose souls do bear an equal yoke of love."
> —"*Merchant of Venice*," III. iv. 12, 13.

On 1st September Richard Hathaway of Shottery, being sick of body, made his will. It was proved 9th July, 1582. Probably, betrothed prior to her father's death—the custom of allowing a decent interval to elapse between a death and a wedding being observed—an application for license for wedlock was presented to the consistory court of Worcester and granted 28th November, 1582—Fulke Sandells, a trusty friend and neighbour, and John Richardson being the responsible sureties. This marriage, no doubt, took place a few days afterwards. Shakspeare did not quit his native place when he married. The young housekeepers would be well settled by Christmas. In the register of the parish church, 26th May, 1583, the baptism of his daughter is noted. The name given her was Susanna, suggestive of

> "A lily pale with damask dye to grace her."
> —"*Passionate Pilgrim*" (87).

In the same book (2nd February, 1585) twin names appear—"Hamnet and Judith, son and daughter to William Shakspeare." Thus, while

> "Three April perfumes in three hot June's burned,"
> —*Sonnet*, civ. 7.

Shakspeare had become the parent of three children, and, in some short time thereafter, driven, a doubtful tradition says,

by a deer-stealing adventure, resolved to push his fortune in London—perhaps carrying with him the rough draft of "the first heir of his invention," "Venus and Adonis," in the hope that "the elegancy, facility, and golden cadence" of its poesy might win him patronage and employment. Ready to put his hand to any honest work, he found the stage making steady demands for novelty, and he became a purveyor of plays. We know some of the men among whom he rose. They belonged mostly to the scholastically-trained, who had got rather off the main line of life and found themselves enforced by necessity to enroll themselves in the list of those who "trickt up," as they said, "a companie of taffeta fools with their feathers," and were fain to "repose eternity in the mouth of a player," and thus sent poetry "abegging up and down the countrie." They felt uneasy when "those that never ware gowne in the universitie" were seen "to leave the trade of Noverint, whereto they were bred, and busie themselves with the indevors of art," especially applying, as Nashe does, the censure to one to whom "English Seneca, read by candle-light, yeelds manie good sentences—as 'Bloud is a beggar,' and so forth; and if you intreate him faire in a frostie morning he will afford you whole 'Hamlets,' I should say handfuls of tragical speeches." Robert Greene, to whose "Menaphon" (1589) Thomas Nashe had prefixed the epistle from which the foregoing phrases are taken, died in September, 1592, leaving behind him his "Groats Worth of Wit," in which he refers to "an upstart Crow, beautified with our feathers, that with his *Tygres heart wrapped in a players hide* supposes he is as well able to bumbast out a blanck verse as the best of you; and being an absolute *Johannes factotum*, is in his own conceite the onely Shaks-scene in a country." Probably this upstart Crow has a depreciatory reference to Spenser's lines in "Colin Clout's come home againe" (1591).

> "And there, tho' last not least, is *Aetion* [Gr. *aetos*, an eagle]
> A gentler shepherd may nowhere be found,
> Whose muse, full of high thoughts' invention,
> Doth like himself heroically sound."

Chettle edited Greene's booklet, and finding that offence was taken at these words apologizes for having let the embittered sentences pass under his supervision into public view. By 1592 Shakspeare had made a place for himself, not among the players and playwrights of London alone, but among the patrons of poetry as well; and in April, 1593, by the issue of "Venus and Adonis," he set forth his claim to a place on England's bead-roll of poets by his use of these lines from Ovid's "Amores," I. xv., as a motto on the title-page:—

> "Vilia miretur vulgus; mihi flavus Apollo,
> Pocula Castalia plena ministret aqua."

Lines which Marlowe had even then translated thus:—

> "Let base-conceited wits admire vile things,
> Fair Phœbus lead me to the Muse's springs."

This poem was dedicated to "Henrie Wriothesley, earle of Southampton," and "imprinted by Richard Field," son of Henry Field, tanner in Stratford-upon-Avon, an early neighbour and friend of the Shakspeares; so was "Lucrece," issued in May, 1594. These two poems, describing the malign influences of inordinate passion, melodious in phrase, luxuriant in imagination, exquisite in feeling, and dainty in diction, won instant popularity and established his reputation as one of the most pregnant of those wits who wore the laurel. From the semi-anonymity of a caterer for the stage he issued into the name and fame of a popular poet. In June, 1594, "Titus Andronicus" was performed at Newington Butts by the lord chamberlain's players, of which company Shakspeare was a member, as we learn from an entry in the MS. accounts of the treasurer of the chamber, which reads thus:—"To William Kempe, William Shakspeare, and Richard Burbage, servauntes to the Lord Chamberleyne, upon the Councell's warrant dated at Whitehall xvto Marcij, 1594, for two severall comedies or enterludes showed by them before her Majestie in Christmas tyme laste paste, viz. upon St. Stephen's daye [26th December] and Innocentes daye [28th] xiij*li.* vj. s. viij*d.*, and by waye of her Majestie's reward, vj*li.* xiij*s.* iiij*d.* in all xx*li.*" These performances took place at Greenwich Palace. On the evening of these holidays last mentioned, a "Comedy of Errors" was played by the players at Gray's Inn. John Weever, in his "Epigrams" (1595), has one on "honie-tongued Shakspeare" (iv. 22), in which, after referring to his two poems, he mentions "Romeo" and "Richard" as characterized by "power-attractive beauty;" and Richard Carew in the same year, while extolling "the excellencie of the English Tongue," suggests that if we want a match for the brilliant imagination, polished verse, easy style, and natural humour of the Latin poet Catullus, we would find it in Shakspeare. Similar praise is deliberately and circumstantially awarded to him in the "Palladis Tamia; Wit's Treasurie," by Francis Meres, M.A. of both universities, a clergyman and schoolmaster in Lincolnshire. This book, entered on the Stationers' Registers, 7th September, 1598, mentions William Shakspeare among those by whom "the English tongue is mightily enriched and gorgeously invested in rare ornaments and resplendent (h)abiliments." "The Muses," he says, "would speak with Shakspeare's fine-filed phrase, if they would speak English." He regards Shakspeare as one of "the best lyric poets, the most passionate among us to bewaile and bemoane the perplexities of love." "As the soule of Euphorbus was thought to live in Pythagoras, so the sweete wittie soule of Ovid lives in mellifluous and honey-tongued Shakspeare; witness his 'Venus and Adonis,' his 'Lucrece,' his sugred sonnets among his private friends," &c. In regard to comedy and tragedy "Shakspeare among the English is the most excellent in both kinds for the stage; for comedy, witness his 'Gentlemen of Verona,' his 'Errors,' his 'Love's Labour's Lost,' his 'Love's Labour's Wonne,' his 'Midsummer's Night Dreame,' and his 'Merchant of Venice;' for tragedy, his 'Richard II.,' 'Richard III.,' 'Henry IV.,' 'King John,' 'Titus Andronicus,' and his 'Romeo and Juliet.'" Meres thereafter asserts the everlasting enduringness of Shakspeare's works. In this little 12mo we find the public opinion of the time expressed by a scholarly man regarded as a guide in these matters, enthusiastically endorsed and definitively expressed. It shows us—between 1585 and 1598—the Stratford youth transformed into a writer of high repute and a person of social position and professional popularity, who had added to life-quick poems some sonnets and lyrics, and twelve plays at least; for those named are not quoted as all, but as examples confirmatory of the statements ventured upon. Five only of these plays were then published, viz., "Romeo and Juliet," "Richard II.," and "Richard III.," in 1597; and "1 Henry IV." and "Love's Labour's Lost," in 1598. The last bore on the title page that it was issued "as it was presented before her Highness this last Christmas, newly corrected and augmented by W. Shakspeare."

In 1587 he gave his assent to the filing of a bill in Chancery for the recovery of his mother's estate of Ashbies, Wilmecote, which had been (temporarily) mortgaged by his parents, and was now wrongously retained in the possession of his cousin, John Lambert, the heir of the original mortgagee. He was one of the men-players at the Blackfriars and the Globe, and was among "those deserving men" whom Cuthbert and Richard Burbage "joined with themselves as partners in the proffites of that they call the House," after the death of their father, James Burbage (1597). "Titus Andronicus" was performed 23rd January, 1594, and entered on the Stationers' Register for publication. On 3rd March, 1592, "Henry IV." was acted, and was so popular that it was witnessed by 10,000 spectators at least within four months. A surreptitious and tinkered up edition of "Henry VI.," under the title of "The First Part of the Contention betwixt the Houses of York and Lancaster," was published in 1594, and the "3 Henry VI.," quoted by Greene in 1592, was imperfectly reproduced in type in 1595. In the summer of 1596 "Romeo and Juliet" was produced at the Curtaine Theatre, and met with great success. On the 11th August Shakspeare's only son, Hamnet, was buried at Stratford. William Dethick, garter king-at-arms, granted on 20th October, 1596, letters patent that it shall be lawful "for John Shakspeare, Gent. and for his children, issue, and posteritie," to wear and show "a shield or coat-armour," and in 1599 the same was regranted by Dethick and William

Camden, the Clarencieux king-at-arms, with the motto *Non sans droit* (Not without right). At Eastertide (1597), William Shakspeare bought from William Underhill the mansion of New Place, with nearly an acre of land, in the centre of his native town, for £60. On 4th February, 1598, when corn had reached a famine-price, he was holder of ten quarters in the chapel ward, wherein this new property was situated. Abraham Sturley had learned from his brother-in-law, Richard Quiney, that "our countriman, Mr. Shaksper is willing to disburse some monei upon some odd yarde land or other at Shotteri or near aboutte us," and suggests that Quiney might move him "to deal in the matter of our tithes." The same Richard Quiney applied to his "loveing good ffriend and countriman, Mr. Wm. Shackspeare, craveing help with xxx*ll*," and on the same night informs Sturley, "our countryman, Mr. Wm. Shakspeare, would procure us money" for the use of the corporation of Stratford for the improvement of the town. On or before 22nd July, 1598, "The Merchant of Venice" was put on the stage, for then James Roberts entered both it and "Love's Labour's Lost" on the Stationers' Register, and in September, by the good offices of Shakspeare Ben Jonson's "Every Man in his Humour" was accepted by the lord chamberlain's company, and the great dramatist took a leading part (probably[?] Young Knowell) in it. Thus we see a fair success gained in every direction by "William Shakspeare of Stratford-on-Avon, in the county of Warwick, gentleman," as he is now legally styled.

Meres had mentioned Shakspeare's "Sugred Sonnets," and in 1599 there was issued a tiny volume, bearing the taking title of "The Passionate Pilgrim," by William Shakspeare, consisting of verses which W. Jaggard had got hold of from any quarter he could, and published as a catchpenny. In the first division, entitled "Sonnets to Sundry Notes of Music," there occur three passages from "Love's Labour's Lost" and two sonnets (138 and 144) which were subsequently inserted in the authorized edition, and some other verses culled from other sources. Thomas Heywood informs us that Shakspeare was displeased at Jaggard's trading thus on his reputation, and we know that a fresh title was issued without Shakspeare's name on it. In "England's Parnassus," "England's Helicon," and "Belvidere, the Garden of the Muses," three collections of selected quotations from the poets (in 1600), nearly a hundred are taken from Shakspeare. The following entries made this year on the Stationers' Registers, show the demand for and appreciation of his plays as literature:—"As You Like It," "Henry V.," "Much Ado About Nothing," and "2 Henry IV." on 4th, 14th and 23rd August, and "Midsummer Night's Dream" and the "Merchant of Venice" on October 8 and 28. To Robert Chester's "Love's Martyr or Rosalines," Shakspeare, along with the best and chiefest of our modern writers, contributed some verses on "The Phœnix and the Turtle," an allegory of the sympathy of souls. In the same year he sued John Clayton for a sum of £7, and recovered the money.

Some of the conspirators in the Essex rebellion, thinking to suggest a revolution, planned that on 7th February, 1601, "Richard II." should be performed in the Globe. This was done, and Elizabeth took the incident keenly to heart, regarding that king in the play as an allegory of herself—one to be deposed if not slain. In the same year, 8th September, John Shakspeare, the poet's father, was buried—having in all likelihood died a few days previously, in his own house in Henley Street, and William Shakspeare succeeded as heir to the ownership of his freeholds and estates. "Twelfth Night" was performed in the Middle Temple, 5th January, 1601–1602. In the following May the great dramatist bought from the Combes 107 acres of land, near Stratford, for £320, and a fresh title was taken for New Place. Conveyance was delivered to his brother Gilbert for his use. On 28th September Walter Getley sold to Shakspeare a small copyhold of a cottage and garden in Chapel Lane, subject to personal appearance in the court of the Manor of Rowington. "The Merry Wives of Windsor" was published 18th January, 1601–1602, and on 26th July, 1602, "The Revenge of Hamlet" was entered on the Stationers' Registers, though it was not published till 1603, and then in an imperfect form. The same printer renewed "Hamlet," and entered "Troilus and Cressida," which, however, was not published till 1608-1609. Shakspeare's company played at Whitehall, 26th December, 1602, and were summoned to Richmond on Candlemas, 2nd February. On 24th March, 1602–1603, Queen Elizabeth expired.

Her royal successor, James I., arrived in London, 7th May, 1603; and ten days afterwards, at Greenwich, conferred letters-patent on Laurence Fletcher, William Shakspeare, Richard Burbage, Augustine Philipps, &c., as his servants, who took rank at court as such among the grooms of the chamber. On the formal entry into London, Shakspeare and his fellows, clad in their scarlet liveries, walked in the royal train from the Tower to Westminster. "Othello" was presented at Whitehall 1st November, 1604, and in the Christmas holidays following "Measure for Measure" was performed. On 4th May, 1605, Augustine Philipps, in his will, left "to my fellowe, William Shakespeare, a thirty-shilling peece in goold;" in July, Shakspeare bought the unexpired term (having thirty-one years to run) of half of the lease of the tithes of Stratford, Old Stratford, Bishopton, and Welcombe for £440. At Whitehall, in 1606, the Christmas play was "King Lear," and, on 5th June, 1607, Susanna Shakspeare, the poet's eldest daughter, was married at Stratford-on-Avon to John Hall, M.A., a well-educated and eminent physician. On 31st December of the same year Edmund Shakspeare, who under his brother's care was a player (probably of female characters), was buried in St. Saviour's, Southwark, with a "forenoone knell" of the great bell. He was only twenty-eight years of age. Shakspeare was made a grandfather by the birth of the only child of the Halls, who was baptized 21st February, 1608. Shakspeare stood as a mourner at the grave of his mother, 9th September, 1608, and might well have said—

> "Of thy deep duty more impression show
> Than that of common sons."
> —"*Coriolanus*," V. iii. 51, 52.

"King Lear" was twice printed in 1608. "Pericles" and "Antony and Cleopatra" were registered 20th May, but the latter was not printed and the former was not issued till 1609, in which year both it and "Troilus and Cressida" passed twice through the press. In 1609, too, appeared "Shakspeare's Sonnets never before imprinted"—showing that Jaggard's book was not to be taken or mistaken for this. He was just then retiring to family life at Stratford, among friends, kindred, neighbours, and gossips, and was unlikely in these circumstances to thrust before the public any shameful secret of metropolitan life. They are weighty with thought, ingenuity of expression, and a lofty sense of friendship, love and life, beauty, fidelity, and grace of heart.

The Records of Stratford show that Shakspeare kept his accounts carefully and looked after business. He had sold, between March and May, 1604, several bushels of malt to Philip Rogers; and as he did not pay, Shakspeare instructed his Cousin Greene to take him into court. In 1608-1609 John Aldenbrooke, who was indebted to him, managed to baffle him for nearly a year by getting beyond the bounds of the borough. Shortly after 1609 Shakspeare was involved in a suit as part owner of the Stratford tithes, in regard to some commutations for which he had arranged; but by 1613 the matter appears to have got settled amicably. In the early part of 1610 he bought from the Combes an additional 20 acres of pasture-land. We have Dr. Forman's evidence that "Macbeth," "The Winter's Tale," and "Cymbeline" were performed in 1611; and on 1st November, 1612, before King James at Whitehall, "The Tempest," with the incidental music arranged by Robert Johnson the royal musician. Richard Shakspeare was buried at Stratford, 4th February, 1613. In March, William Shakspeare negotiated the purchase of a house a little distance from Blackfriars Theatre, London, for £140, leaving £60 of the price on mortgage. The Globe Theatre was destroyed by fire, 29th June, 1613, but was rebuilt on an improved plan in 1614. This probably engaged Shakspeare in London, where he was when the corporation of Stratford asked his help to oppose the inclosure of the commons at Welcombe. Shakspeare aided them in this, even against his own interests and

despite of the offer of the projectors of the inclosure to give satisfaction to himself and Dr. Hall, to buy off his powerful opposition. Early in 1616, he had preparatory notes made for his will. On 10th February, Judith, the poet's youngest daughter, was married to Thomas Quiney, vintner, Stratford. Ben Jonson and Michael Drayton visited him at New Place probably on this occasion. His will, which was at first signed 25th January, had its date altered to 25th March. Then came the last scene, 23rd April, 1616, just as his fifty-third year dawned, and in the burials register this entry appears—"1616, April 25, Will. Shakspeare, Gent." He was laid to rest in the chancel of the church of the Holy Trinity, and is there "so sepulchred," as Milton says,

"That kings for such a tomb would wish to die."

A monument was erected to his memory, whereon he is likened to the immortal three, Nestor, Socrates, and Virgil. On 8th August, 1623, Anne (Hathaway) Shakspeare was laid in the grave next to that in which he was interred, and on 8th November, "Mr. William Shakspeare's Comedies, Histories, and Tragedies" were presented "to the great variety of readers" by his fellows Heminge and Condell. Besides the plays already mentioned, this volume contained, "Measure for Measure," "The Winter's Tale," "All's Well that Ends Well," "Twelfth Night," "Henry VIII.," "Coriolanus," "Macbeth," "Julius Cæsar," "Cymbeline," "Pericles," and "King John;" and it forms one of the most valuable gifts to the human race which has, as yet, issued from a single mind—so fraught is it with thought, wisdom, humour, and imagination. Ben Jonson therein rightly characterized Shakspeare as the

"Soule of the age,
The applause, delight, the wonder of our stage."

Such he was, such he continues. In strength of thought, universality of sympathy, superiority of poetic power, he is still unrivalled. By the divine right of the kingliest to be king he is still the lord of song. Eulogy has exhausted itself in his praise, and yet has not overdone it. Carlyle has rightly said, "Shakspeare is the chief of all poets hitherto: the greatest intellect who in this recorded world has left record of himself in the way of literature. On the whole I know not such a power of vision, such a faculty of thought, if we take all the characters of it, in any other man." He had his life to live and he did so, he had his work to do and he did it, he had human nature to mirror and he reflected it fully and faithfully.

Such are the more important of the few grains of biographic fact which have been sifted from vast sheaves of books, pamphlets, registers, records, diaries, monuments, muniments, &c., repositories of manuscript notes and jests, facts and fancies, regarding things important to Shakspeare and interesting to us about him who occupies the foremost reach of poetical excellence and practical intellectuality. Shakspeare, the creator of nearly a thousand living characters, brimful of specific personality, lived, by choice, the private impersonal life of an Englishman. He was content to be an influence, and cared not to strut and fret and stage himself before his countrymen in any other than in a professional manner. He cared not for the notoriety of noise, but for the popularity of present effectiveness upon the people as a dispenser of joy and an inciter to thought. He taught in the theatre that character is all in all in man—shaping his life and destiny, and he put into pithy pellets of poetry the supremest truths regarding thought, feeling, passion, and purpose he could gather by reading or reflection. The one indispensable quality of an efficient instructor he had—the power to interest men's minds, and so to make them receptive of "high thoughts' invention." His sympathies were wisely and widely human, his vision of the operation of motive and result in man's doings and dealings was clear, his power over expression was perfect. He revealed the inner secrets of the heart, and showed men how happiness or woe took each its origin in the principles or passions which ruled it. Irresolute Hamlet, puzzling over life's mysteries, brings about confusion and death. Selfish Macbeth finds sovereignty no solace for the sense of sin, and the grievous gloom of depression ending in sadness and suicide falls upon that usurper's wife as his accomplice. Othello's hot-passioned indiscretions, notwithstanding nobleness and courage, result in ruin to home and hope. Falstaff's indulgent life, though flecked with moments of mirth, is flushed with self-reproach and finished in sadness. The unreasonably despotic second childishness of Lear works worlds of woe and deepens into despair. Angelo's shallow self-satisfied saintliness lacks the sustaining strength of principle and lands the egotist in sin and shame. Antony and Cleopatra, lust-lost, lastingly injured the world. Pure-souled Imogen suffers for the reckless boasting of Posthumus. History unfolds itself to us in a living panorama on his reflective stage, and nature has never suffered her models to be similarly used by any other imitative creator. Out of a manhood of but thirty years never has there been distilled such precious products. Well did Thomas Thorpe designate him "our ever-living poet."

Henry Chettle, in whose "England's Mourning Garment" (1603) Shakspeare is referred to as "the silver-tongued melicert," and who, in 1592, bore witness to his being known and respected by "divers of worship," was also born in 1564. He was author of sixteen plays and a contributor to thirty-two others. Of his independent work, "Hoffman, or a Revenge for a Father," acted 1602, alone survives. He, Dekkar, and Haughton conjointly produced "Patient Grissel," the theme, but neither the poetry nor spirit, of which is taken from Chaucer, although the following lines give a fine word-painting of the heroine :—

"See where my Grissel and her father is ;
Methinks her beauty, shining thro' these weeds,
Seems like a bright star in a sullen night.
How lovely Poverty dwells on her back!
Did but the proud world note her as I do,
She would cast off rich robes, forswear rich state,
To clothe her in such poor habiliments." (I. 285–292.)

In 1592 Chettle was certainly well known and reputed in theatrical circles. Meres speaks of him as "one of the best for comedy." He was engaged, in 1599, with Dekkar in writing "Troilus and Cressida," probably got up hastily to forestall a play then in rehearsal by the lord chamberlain's men, entered on the Stationers' Register 1603, and, early in 1609, issued as "a new play, never staled with the stage," "written by Wm. Shakspeare." He and Robert Wilson also wrote "Cataline's Conspiracy," which, however, has not, like Ben Jonson's, passed into print. Jonson, Dekkar, and Chettle were engaged in September, 1599, on a tragedy on "Robert II., King of Scots." It is impossible to distinguish his work from Munday's in "The Death of Robert, Earl of Huntingdon." His "Blind Beggar of Bethnal Green" was not printed till 1659. He was undoubtedly associated with the stage before 1592, when he edited Greene's "Groats Worth of Wit." In his "Kind Harts Dreame" we have an early notice of Shakspeare as excellent in the quality he professes. Chettle is supposed to have died about 1607.

Thomas Dekkar, "a priest in Apollo's Temple many years," in his "Rod for Runnawayes" (1625), says: "O London, thou mother of my life, nurse of my being," and so fixes incidentally his birthplace, as he does also in his "Seven Deadly Sinnes of London." He was probably educated at Merchant Tailors' School. In "Dekkar his Dreame" (1620) he hypothetically remarks—"Say that full sixty years my glasse did runne," and in the epistle dedicatory to "English Villanies Several Times Prest to Death" (1637) he speaks of "my threescore years, devotedly yours in my best service." This would take his birth-year back to about 1560. His life, so far as we know it, was a constant struggle with poverty, spent "in much patience, in afflictions, in necessities, in distresses, in imprisonments, in labours, in fastings," stoutly maintaining his right to be regarded as a gentleman. Through good report and through bad report he aimed to be a humble, faithful follower of Him whom he thus finely describes :—

"The best of men
That e'er wore earth about him was a sufferer,—
A soft, meek, patient, humble, tranquil spirit,—
The first true gentleman that ever breathed."

In that sad memorial of the monetary miseries of playwrights, "Philip Henslowe's Diary," he is frequently noted as a receiver of advances, loans, doles to discharge him out of the compter or free him from arrest. Yet, with elastic spirit and brightness of wit, with wholesome morale and whole-hearted honesty, he seems to have done his hack-work with some sunshine of soul. Even the surviving relics of his multifarious labours have supplied four volumes of "Dramatic Works" in Pearson's edition, and Dr. Grosart, who has collected his "Non-dramatic Works" into five volumes, says of him—

> "Many a manners-painting book he writ,
> Packed full of quaintest wit and play of will."

Cyril Tourneur, one of the most energetic and epigrammatical dramatists of this time, is known only by his writings. He is one of the most successful disciples of the school of Shakspeare. In 1600 there issued from the press a satire from his pen, entitled "The Transformed Metamorphosis," intended to foreshadow what England might become. His "Revenger's Tragedie" appeared "as it hath been sundry times acted by the king's Majesties servants," in 1608. On 15th February, 1611, there is entered on the Stationers' Register "The Nobleman," a tragi-comedy by Cyril Tourneur. It was not printed, and the MS. was destroyed by Warburton's servant. "The Atheist's Tragedy," "as in divers places it has often been acted," was printed in 1611–12. Its plot is partly founded on Boccaccio's "Decameron" (VII. vi.) J. A. Symonds, in his "Shakspeare's Predecessors," says, on what authority we know not, that "Cyril Tourneur took a company across the seas to act in Flanders" (p. 297). In Peter Cunningham's "Extracts from the Accounts of the Revels at Court" (Introduction xliii.), a quotation shows that Tourneur got on "23rd December, 1613, for his charges and pains in carrying letters for his Majestie's service to Brussels x *li*." The lesson of the "Atheist's Tragedy" is "that patience is the honest man's revenge" (V. ii.)

We shall pass on, in our next lesson, to consider the successors of Shakspeare as stage purveyors. Meanwhile we may say that we have seen how the drama arose, attained popularity and power, and became for the time being a professional pursuit. We have learned also under what circumstances men of genius either drifted or were drifted into the ranks of play-making poets; and in what manner among a public not educated to read, the stage rose in public estimation and acted as an educator—each theatre becoming a place of public resort, the frequenters of which spent their time in "hearing some new thing," struck off at fire heat from the minds of men full of exuberant life, adventurousness of thought, and rare extemporality of utterance. We have also seen how the plant of poetry grew into richer beauty and more perfect fruit, and acquired, in a brief space, the higher glories of artistic ripeness and of intellectual supremacy.

One thing more, however, requires to be emphasized—the marvellous influence the drama has had on the language of the English race. Owing to the drama's characteristic of exhibiting thought, not only in poetic speech, but in conversational forms, necessity was laid upon its craftsmen to acquire and employ a vocabulary of vast range, apt expressiveness, and yet so plain and effective that it could be understood by all. All the life of man demanded utterance in speech specific, characteristic, and popular, and these men, from all parts of the country, from all grades of society, from every class of the community, from differing schools, universities, conditions of fortune, and modes of living, brought their mother tongue and their acquired language into immediate use for the expression of every possible form of thought, emotion, aspiration, and desire. As their success depended on the impressiveness of their productions on the general mind, and that again upon the expressiveness of their language, they required to employ and select popular, graphic, and suggestive phraseology. Thus the English were supplied with a fresh, potent, varied, practical, yet poetical, popular form of speech, which, greatly to the advantage of literature, was made graphic before it became lexicographic, and prior to its diction being embalmed in dictionaries.

HISTORY.—CHAPTER X.

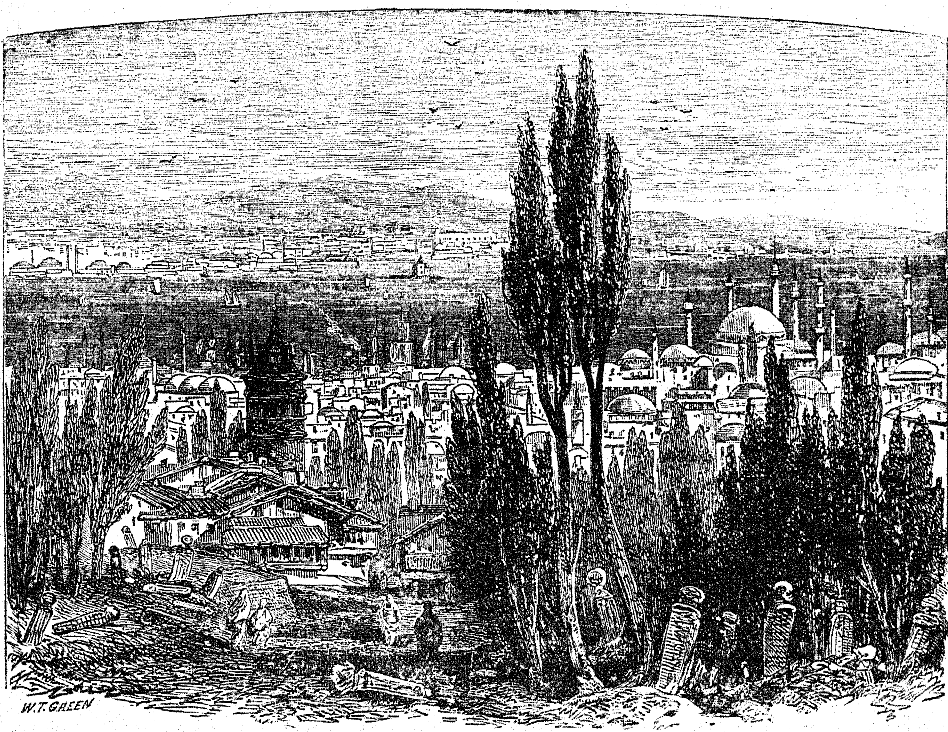
CONSTANTINE—THE RISE OF THE CHURCH—THE RIVAL CITIES—ROME AND CONSTANTINOPLE—THE DIVISION OF THE EMPIRE—ALARIC THE GOTH—ATTILA THE HUN—GENSERIC THE VANDAL—THE FALL OF ROME.

CONSTANTINE was one of the most famous of the Roman rulers; the first of the Christian emperors, and yet no saint; the abolisher of heathen ritual, though even heathendom declared it had no expiatory rites for the cleansing of such characters as his; a Roman emperor, and yet the founder of a rival city, to which he transferred the wealth, magnificence, and power of Rome, but to which even he could not impart "the stirring memories of a thousand years," nor the glories of unequalled soldiers, statesmen, and sovereigns. Constantinople, built on the extreme boundary of Europe, and separated from Asia only by a narrow sea-passage, was contrived to hold the place of dominion over three continents—the arbitress of the world's fate. Constantine had the monarchic mind, the policy of pre-eminence founded on a definitely graded system of rank and dignity—owing its value to the imperial commission and its relation to the throne as "the fountain of honour." He arranged a two-fold aristocracy—one of title and wealth for show, and one of place and power for use. To him we owe the first General Council of Nicæa and the formulated Nicene creed, which was to form the firmly-founded basis of the Christian faith. The new Rome which he built was intended to be the home of a Christianity managed on the monarchical model, and moulding all faith to its forms and all life to its laws. Constantine lived long and established his power firmly. When he died (337) his empire was divided, by a treaty made in Pannonia, among his three sons, Constantine, Constans, and Constantius, but by 350 its parts were again united under Constantius, who had been proclaimed Cæsar in 320, assumed the purple on his father's death, and chose the East as his share of the dominions. There were many revolts and much rivalship during his reign, as well as many disputes in the church. Julian, his cousin, Cæsar of the West, having ejected the Germans from Gaul, was proclaimed Augustus by his soldiery, and Constantius dying soon afterwards (361), Julian took his place on the imperial throne. Julian had been brought up as a Christian, and was in his own life irreproachable. He was young, vigorous, talented, but he had become a worshipper of the fallen gods, fancifully allegorized into representatives of powers and qualities, and fitted into a new philosophic creed. Hence he was called Julian the Apostate. The old religion, thus patronized, warred against the new. Julian did not so much persecute as scorn, so much resist as contemn. Sapor, king of Persia, acting on the aggressive, brought Julian into the field. An arrow—some said from an angel's, some from an assassin's hand—laid the emperor low. Like the dying Socrates, Julian, surrounded by his friends, conversed with composure and fortitude on philosophic speculations, and died the night after receiving his wound, 26th June, 363. Jovian saved the army serving in Persia, made peace with Sapor, was chosen by the soldiery as emperor, and on his arrival at Antioch repealed Julian's edicts against the Christians. He laid the remains of Julian with funeral honours in a tomb in Tarsus, and while journeying to Constantinople was found dead in bed, 17th February, 364, at Dadastana, in Galatia. Valentinian and Valens, brothers, were named emperors of the Roman dominions, and amicably arranged to divide the empire into the East, governed by Valens at Constantinople, as the watchguard of the Danube and the Euphrates, and the West, under Valentinian, with an imperial residence at Milan, to manage Italy and Gaul. Thereafter history diverges into two streams, with Rome and Constantinople respectively on their banks.

The Goths had been settled many years on the Danube's northern bank, and had formed a kingdom in Trajan's Dacia. Under the training of Ulfilas—whose translation of the Scriptures into their tongue is the oldest Teutonic literary treasure we possess—they were being rapidly disciplined to Christianity. Suddenly there broke in upon them, like a storm, an invading horde of Huns. These Turanian tribes had been driven out of the eastern parts of Asia, and made

their way, amid grievous hardships, into Europe. They were seeking rest for the soles of their feet. The terrified Goths besought Valens for a place of safety on the southern side of the Danube. They received passage, having surrendered their children and weapons to Roman care. The latter they speedily redeemed, and Fritigern, their leader, in resentment of the ill-treatment to which they were subjected, threatened revolution. Valens indignantly met them in battle at Adrianople. They fought with the fury of despair. Two-thirds of the Roman army perished, and Valens was burned to death in a cottage where he had sought refuge, to which his pitiless pursuers set fire. The Goths advanced to the walls of Constantinople, but were, after cunningly conducted negotiations, bought off.

Thus Theodosius the Great, who was called to the throne and reigned first as the colleague and subsequently alone, contrived to stave off the evil day. He was the last of the emperors who ruled over the entire empire. When his two sons, Honorius and Arcadius, succeeded, they divided the sovereignty, the former taking the West, the latter the East, and made dismemberment possible. Alaric, the bravest of the warriors of the West Goths, made a terrible onset on



Constantinople.

Rome, which, although for a while impeded by Stilicho, ended at last in the capture and sack of the city that had been free from a foreign foe since Brennus, *regulus Gallorum*, B.C. 382, plundered and burnt it, but paid dearly afterwards for his rapacity by the total slaughter of his forces. Alaric, who had accomplished a feat which had been found impossible by Pyrrhus, king of Macedonia (278 B.C.) or Hannibal of Carthage, died soon after, and was buried under the rolling waters of the Busentino. Ataulf, Alaric's brother, made a treaty with the empire, cemented by his marriage with the sister of Honorius. He undertook to quell the revolted provinces, and as a Roman officer went into Spain to restrain the German tribes pressing on all sides into Gaul, and passing thence into the peninsula. Ataulf was murdered, and the emperor making a virtue of necessity, ratified the possession of these territories to those whom he could not expel. The fourth century was thus not twenty years old when three separate kingdoms were established in Europe. The empire thus dismembered, and with its dismembered parts erected into hostile kingdoms in the West, had great difficulty in warding off the attacks made on it by Persia in the East, where Varannes, under Ardabarius, the general of the effeminate Theodosius II., was at length defeated in 421, and a peace was concluded which lasted till the death, not only of the king, 28th July, 450, but of his sister Pulcheria, three years thereafter. The relations of the emperors were considerably complicated, and the empire gradually grew more and more unsafe.

At length, not only the Romans of the empire, but the Goths and their Teuton kin settled in the empire, were amazed by the threatening advances of a horde of Turanian tribes, under a savage potentate, who claimed a place in Pannonia and Thrace, and spread terror and devastation wherever they went. Three-quarters of a million of these marauders, ravaging and conquering under Etzel, otherwise Latinized into Attila, were found rather uncomfortable invaders by Theodosius, especially after they had thrice defeated the imperial forces. A tract of land, extending to fifteen days' journey in breadth, along the banks of the Danube, was vainly conceded. To each emperor Attila sent a messenger saying, "My lord and thy lord Attila" commands thee to prepare a palace for his immediate reception. Marcion, who had by this time succeeded Theodosius, replied, "I have gold for my friends, steel for my enemies." Attila claimed the hand and fortune of Valentinian's sister Honoria, and was refused. Under pretext of assisting Genseric, king of the Vandals, against Theodoric, king of the Goths, Attila marched through Germany to the Rhine, defeated the Franks, cut down forests, built boats, crossed the river, entered Gaul, and besieged Orleans. Ætius and Theodoric, leading the Romans and the Goths, compelled him to retreat. Finding at Chalons-sur-Marne an extensive plain well suited for the evolutions of the cavalry of his Hunnish tribes, he waited the assault of the combined troops of Italy and France. There one of the most sanguinary contests recorded in history occurred. Three hundred thousand corpses were left on the field as evidence of the severity of the struggle. Though Theodoric was slain, victory declared for the West. Attila retreated from Gaul into Pannonia in 451. Having reinforced his army, he proceeded to Italy, there to claim the princess and her dowry. The Alps were crossed by numerous passes by an avalanche of cavalry. Aquileia, after a three

months' siege yielded, but was destroyed. Vicenza, Padua, Verona, Mantua, Cremona, Brescia, Bergamo, were spoiled and burned. Milan and Pavia, finding resistance vain, capitulated and were mercifully dealt with. Then he advanced on Rome. When encamped on Lake Benacus, Pope Leo I. and Avienus sent as an embassy from Valentinian III. conciliated Attila, and prevailed upon him to retire beyond the Danube, where he died in 453, leaving no lasting memorial of his conquering and devastating energy. The disputes and dissensions of his sons and chieftains speedily wrought the ruin of the hastily erected throne he had built up, and left to the world little else than a name of fear.

The conquest of the shores of Africa by a Vandal host raised once more the city of Carthage into a rival of Rome. Sicily, Corsica, and Sardinia formed parts of this new state. Its fleets commanded the Mediterranean and threatened both Constantinople and Rome. Genseric, the ally of Attila, did not feel inclined lightly to lose the spoil of the Roman world. An opportunity soon arose of gratifying his desire. Petronius Maximus, having assassinated Valentinian III., compelled his widow Eudoxia to marry him. She, stirred by rage and revenge, sought aid from Genseric. He dashed over from Africa, pillaged Rome for fourteen days, carried off the empress with him, and away to Africa again. The kings of the Goths and of the Suevic tribes of Germany raised to the purple whom they chose. Avitus was a mere puppet. Majorian (457–461), a wise and brave man, was assassinated in order that Ricinus might reign, while the Lucanian Severus nominally occupied the chair of state, 461–465. Anthemius, Olibius, Glycerius, and Julius Nepos successively played the part of shadow sovereigns. All the while they wore the insignia of empire their nominators bore the sceptre and the sword. The very pretence became contemptible, and when the last youthful inanity—whose name, Romulus Augustulus, recalled the former "the great founder of the city," and the latter the first of the imperial line—was deposed by Odoacer (476) the Roman senate, ashamed of its own phantasmal insignificance, having allowed the leader of the Heruli to assume the title of King of Italy, sent the purple and the sceptre to Zeno, emperor of the East, with the request that he would be sole ruler over the Roman realm. So passed away the imperial glory of old Rome to Byzantium, that new Rome which Constantine, less than a century and a half previously, had founded on the shores of the Euxine, and which was to bear the name of the capital of the Roman World for nearly 1000 years thereafter. The spiritual dominion of Rome took the place of the civic, and while new kingdoms grew into secular might, still held the nations of the world in its firm ecclesiastical grasp.

CHAPTER XI.

THE RISE OF NEW NATIONS—GERMANY—BRITAIN—FRANCE —ODOACER—THEODORIC—CHARLEMAGNE.

A NEW people—the Germanic tribes—have now appeared upon the stage of history, established in the Roman provinces. The earliest information we possess regarding these tribes is neither full, distinct, nor very consistent in itself. The little that is known of them previous to their invasion of the Roman territories is nearly as follows:—

In the time of Cæsar they inhabited an extensive land-stretch north of the Danube and east of the Rhine. The limits occupied by them to the north and east are unknown. It is only through the writers of the Roman Empire that we know anything of them; and only along the Rhine and the Danube the Romans came into contact with them. Their physical characteristics were fair ruddy complexions, light reddish or auburn hair, and blue eyes. Their language, or languages, were kindred dialects. In all of them the logical and phraseological laws are substantially the same; in all of them the radical vocables are similar in form and meaning.

So lately as the time of Tacitus the tradition of a common origin obtained among the Germanic tribes. Whether Tacitus be correct in his names or not, he has preserved an authentic record, of which the meaning seems to be that the Teutones, *i.e.* the descendants of Teut, were originally divided into tribes named, as in the case of the Hebrews, after his sons. One of these tribes came in the lapse of time to split into several clans. These clans, forming themselves into a confederation, each took a common name. Thus each new Germanic state sought to ingraft itself on the original family-tree by attributing to their fabulous ancestor, Mannus, another son, to whom they gave the name which they themselves assumed.

The glimpses of the constitution of society among these tribes which we get from the Roman writers, present to us this view. Every freeman, that is, every male of pure descent, and past his one-and-twentieth year, was entitled to a voice in the public transactions of the settlement or community of which he was a member. In different parts of Germany there were confederacies of several settlements, in which, while the old constitution was preserved for the regulation of local affairs, the public business of the union was managed by the leading men of each community. How they were appointed does not clearly appear. These unions, not satisfied with defence, forcibly incorporated many neighbouring communities and confederacies of Germanic origin, and made war upon the Gauls and other northern races. Hence a class of warriors sprung up, not the freemen, all of whom were warriors, but men who made war their trade—men who, when their own tribe were at peace, were ready to take service with any other people engaged in war.

Of the Germanic mythology we have very imperfect accounts. It is, however, certain that, in the words of Tacitus, "they neither dreamt of confining the gods within walls, nor of likening them to any human form;" that "they consecrated glades and groves, and called by the names of gods *that sacred something which veneration alone discerns.*" "A glade consecrated to the primitive religion is shown among the Naharuali (a clan of the confederacy of the Tygiia, eastward of the Suevi, and separated from them by a mountain ridge); a priest presides in female apparel; they venerate twin gods without image or name." The Angli, their associates, worshipped Herthum—that is, "mother earth." Their sacred place was in an island in the sea, where ceremonies were performed at stated intervals, but where no image was kept. Reverence was paid by all to Teut, the son of Herthum, their common parent. In his sacred glades and groves unbound steeds of pure white were maintained at the public expense, and auguries were drawn from their neighing. Another mode of augury was by lo into a r from a tree was cut into pieces of varyin ed Julian the Aposta bitrary meaning was secretly attache warred against the ne each; these twig-cuts were scattere te as scorn, so much resis e or more required to be picked up Persia, acting on the agg nt mode of augury was used previ d. An arrow—some said fro ptive of the enemy was detaine in's hand—laid the emperor was armed, and set to fight a d an, surrounded by his frie osen warriors. The result of the rtitude on philosophic s hetic. They divined also by the voice receiving his wound

The majority of the German y serving in Pers cies were cultivators of the soil. Their long soldiery as emp e occupied with eating, drinking, and listening ian's edicts ag The chase also was at once an amusement and a s Julian wit e discipline of the warrior. Along the Rhine and the Danube they became acquainted with the use of money. The subjected tribes of Gaul worked for them the iron mines of Rhætium, and thus their poverty in iron weapons, noticed by Tacitus, gradually diminished. The Germanic tribes, north of the Danube and east of the Rhine, maintained their independence despite the most strenuous efforts of the empire. It was found expedient by the later emperors to take into pay the most influential *fursten* (or firsts) of the various followers among the confederacies, next neighbours to the empire, as guards against encroachments from the tribes which lay behind. By this means the wealth and power of these princes were augmented, and in many of the confederacies a rude limited monarchy began to supersede the old republican institutions. Quarrels between these princes and Rome generally ended in some of their families or noblest followers being sent as hostages to the capital, where they not unfrequently picked up some knowledge of Roman policy and

tactics. On their return to Germany ambition and a conscious superiority to their countrymen led them to form bolder schemes of dominion, and thus more remote tribes and new combinations of tribes were introduced to the knowledge of the Romans. At no time was the pure Roman race more than a small fraction of the population of the empire. Incessant wars during the continuance of the republic, and misgovernment under the empire, had materially thinned the population of the provinces, and even of Italy itself. Large bodies of German mercenaries, permanently stationed in garrisons with their wives and families, became, in time, no unimportant portion of the population of the Roman cities. Constant communication was kept up between those Germans domiciled within the empire and their kinsmen beyond the Rhine and the Danube. Raw recruits joined the soldiery, and often a longing for his early home led an old soldier to obtain permission to return to Germany. The Germans rapidly advanced towards an equality of warlike skill with the Romans, whom they far surpassed in robustness. They learned to look down upon the citizens of the empire. Their leaders meantime were, from motives of policy, caressed by the court. The emperors could place more reliance upon their blunt honesty than on that of their corrupt courtiers. We not unfrequently therefore see them filling important stations in the empire towards its close. Thus the insensibly prepared southward motion of the Germanic tribes, when it took place, occasioned changes of dynasties rather than any revolution of a more decided character.

The first visible step of this great movement took place in the year 394. On the death of Theodosius the Great the empire was divided. The eastern half was assigned to Arcadius, and the western to Honorius. This event had important consequences. These were brought about by the enmity between the ministers of the two monarchs. The Goths had sought refuge from the Huns (an Oriental race) in the territories of Arcadius and Honorius. The minister of Honorius, Stilicho, who claimed the wardship of both emperors, intrigued with the Goths resident in his territories, and with their persecutors, the Huns. After a series of hostilities, managed with various degrees of success, he succumbed to a course of intrigue directed against himself, which terminated in his execution at Ravenna early in the year 408. These intrigues issued in the establishment of three new dynasties in as many Roman provinces—those of (1) the Vandals, in Africa; (2) the Goths, in Spain and Aquitaine; (3) the Burgundians, in the upper Rhine and upper Rhone. Britain fell to the lot of a mixed tribe of Saxons, Jutes, and Angles. The Picts and Scots had ravaged the Roman portion of Britain several times before the year 400. The withdrawal of the garrisons from the island between 400 and 404 by Stilicho, and, still more, the subsequent withdrawal of the flower of the troops by Constantine—a common soldier elected Emperor of Britain by the soldiery, who aimed at imperial dominion in the West—left the Britons exposed to the incursions of their wild neighbours. In "The History of Great Britain and Ireland," chap. ii. p. 281, *et seq.*, the reader may follow the course of these incursions at length.

The turn of Rome and Italy to own the Germanic yoke next came. A temporary inroad from a power alike hostile to Rome and the Germans was destined to assail Italy, Burgundy, and the Visigoths as three independent yet allied powers. Attila, the greatest monarch who reigned over the Huns, after a fierce battle with the Romans under Ætius their general, died in the year 453. His death loosened the only tie which held his subject tribes together, and ere many years had elapsed the very name of the Hunnish power had ceased (see p. 682).

Rome had been more than once subjected to external invasion, but the first revolution that was to set a German on the Roman throne came from within. In 476 Romulus Augustulus—called by this diminutive appellation, as if in derisive prophecy—was dethroned by his German guards. All the troops of that race in Italy adhering to their countryman, their commander, Odoacer, was declared king. Odoacer speedily reduced Rome and the whole of Italy. He also obtained the cession of Sicily from Genseric by pacific convention. The imperial title he did not assume, nor did he even call himself King of Italy. He called himself King of the Heruli, Rugii, and Turcitunji (Germanic tribes of the oldest and noblest) in Italy. He formed alliances with the Visigothic and Vandal kings. He was, however, the only king of his dynasty. Theodoric, king of the Ostrogoths, with the sanction of the Byzantine court (in which he had lived ten years as a hostage), crossed the Alps in 489, and in three successive battles drove Odoacer from the field. Odoacer took refuge in Ravenna, was starved into surrender, and not long afterwards put to death by Theodoric. The kingdom of the Ostrogoths thus founded, embraced Italy, Sicily, part of Provence, the country north of the Alps to the Danube, and part of Dalmatia. Although Theodoric, more fortunate in this than Odoacer, transmitted his crown to his successors, his dynasty was not of long duration. The generals of Justinian subdued the Ostrogoths in 554. The southern regions of Italy continued for some time in the hands of the Byzantines; but a new Germanic kingdom immediately sprang up in the north—that of the Lombards, which was founded by Alboin in 568, and lasted till 774.

The Franks first appear in history as a confederacy of independent states on the banks of the Rhine. In 407 they, when borne down by the successive attacks of the Vandals and the Burgundians, were enabled to retain their places by the assistance of their allies the Saxons. From that time till the year 508 they bore the character of invaders, and under their leader Chlodwig (*Ludwig*, *i.e.* famous warrior, in Latin *Clovis*, and in French *Louis*) made various successful inroads on the territories of their neighbours. In 508 Chlodwig was, by the Emperor Anastasius, appointed Patrician of Rome, a title which implied his powers of governor, and the promotion was accompanied by a dress more tasteful and splendid than had ever before been worn by a Frank leader. Fourteen years previously he had been baptized, and this ceremony —for his subsequent life will not allow us to look upon it as anything better—materially forwarded his ambitious views. The inhabitants of Gaul had as a body been general converts to the Christian faith prior to the inroads of the Germanic tribes. The Visigoths, who made themselves masters of the richest and largest portion of France and all Spain, were also baptized, and professed the Arian faith. The clergy of Gaul belonged to the orthodox section of the church; and Chlodwig, having been baptized by them, received from that moment their zealous assistance against the so-called heretic sovereigns. The favours and honours of the court of Byzantium—honours which made the former subjects of the Roman Empire recognize a bond of citizenship between them and the Frank leader, but which implied scarcely even a nominal dependence —facilitated not only the extension of his conquests, but the consolidation of his power. Up to 508 Chlodwig was content to remain the most powerful and influential among the chiefs or kings of the Frankish tribes. He now aspired to be sole king. His end was soon determined by treachery. In power and glory he died in the year 511.

The kingdom founded by Chlodwig remained in his family for 200 years. That family, however, degenerated into imbecility. The Merovingians, as they have been called, were a wicked as well as a weak race; and few dynasties have a history so packed with public and private criminality as that of these early sovereigns of the Franks. In the long run the Merovingians let all real power pass out of their hands, and the mayors of the palace governed while they nominally served. Childeric IV., the last of the dynasty, was deposed in 752, and was succeeded by Charles Martel, who, after successfully resisting the conspiracies of the Frankish nobles, continued to rule without assuming the kingly title. Towards the close of his career the Bishop of Rome, finding himself pressed by the King of the Lombards, and left unsupported by the emperor, sent, in 741, a solemn embassy to the ruler of the Franks. They brought with them the keys of St. Peter's grave, and offered him the Roman patriciate, *i.e.* the office of defender of the Romish chair, with the assurance that the Romans would acknowledge him, instead of the Greek emperor, for their master. For this flattering offer Charles was indebted partly to the habit among the orthodox clergy of regarding the Frankish ruler as the natural rival of the heretic Visigoths, partly to his

own victories over the Saracens in Aquitaine, which had stayed the progress of Islamism in the West. The subject was under serious consideration both at the Roman and Frankish courts when Charles and the Pope who made the offer died. The negotiation was, however, resumed at a later period. At Charles Martel's death the management of the Frankish state was divided among his sons. But in less than three years his son Pepin le Bref had engrossed the whole. By consolidating the conquests of his predecessors, and making new, he added to the Frankish territories Bavaria on the south-east, Saxony on the north-east, Aquitaine on the south. Having accomplished so much he set himself to convert his title of *Major-domus* into that of king. Zacharias, a Greek, was then pope, and Boniface, the archbishop of Mayence, was his legate, with the charge of all the Teutonic churches. Having won this prelate, Pepin found his superior easy to manage. The activity of Pepin and his father in extending and organizing the church in Germany, and the importance of enlisting so brave and powerful a leader as the church's soldier, with a view to any contingent inroad of the Arabs from Spain, were dwelt upon. With the Pope Pepin gained the entire body of the clergy, and with the clergy the whole nation. These securities obtained, Pepin sent two priests to Rome to ask publicly which better deserved the Frankish throne, Childeric, the heir of descent, or Pepin, the heir of his own and his father's actions. The answer of the Pope was all that the Frankish ruler could desire. Pepin was elected king of the Franks, and avouched by the Archbishop of Mayence. Pope Zacharias visited him soon after his coronation, and represented to him in strong terms the oppression the Holy See suffered at the hands of the King of the Lombards. Moved by those statements Pepin marched against the Lombards, forced them to resign all that they had taken from Rome and the Pope; and, besides restoring to the latter what had previously been the domains of the church, Pepin formally transferred to him the Exarchate of Ravenna. The emperor protested against this gift, but in vain. The Greek influence had never entirely sunk in Italy; and this first beginning of territorial sovereignty by the Bishop of Rome was clung to by all his successors in the chair with a tenacity that defied the efforts of the prelates of Ravenna, of the Venetians, and even of Charlemagne to wrest it from them.

Pepin was succeeded in 767 by his son Charlemagne, or Charles the Great. Several of this prince's brothers were originally joined in office with him, but following the example of his father, he contrived to rid himself of them all. He reigned forty-seven years. In the very beginning of his rule he was invoked by Stephen IV. to fulfil his duty as hereditary Patrician of Rome, by reducing his Lombards to peace. At the close of the campaign which he undertook upon this summons Charles was formally installed Roman Patrician, and saluted as king by all the Lombards. Charles confirmed to the Pope by charter the territory granted to that prelate's predecessor by his father Pepin. He subdued all Gaul as far as the Pyrenees. After repeated insurrections, he finally vanquished the Saxons and independent Franks, and added to his dominions all Germany west of the Elbe. On the death of Pope Adrian in 795 Leo III. sent to Charles, as Patrician, the keys of St. Peter's grave and the banner of the city of Rome, and invited him to send one of his grandees to Rome to receive in his name the oath of fealty from the citizens. This step really installed the Patrician in the dignity of Emperor. About the year 799 a feud broke out between the Pope and the relations of his predecessor, Adrian. This ended in a public assault of Leo, and his confinement in a cloister. The citizens of Rome took part against the Pope. Leo, however, having made his escape, laid his complaints at the feet of the Frankish monarch. A still higher ambition seemed now to animate Charles. He crossed the Alps, set on foot a solemn inquisition into the disturbance, reinstated Leo, upon his solemnly clearing himself, by a public oath, of all the accusations made against him; and at the same time, for the purpose of ingratiating himself with the Romans, punished the adversaries of the Pope leniently. This business was finished in November, but Charles prolonged his stay at Rome till the spring. On Christmas Day, 800, he attended the sacred service. As he was rising at its close the Pope placed a costly crown on his head, the people saluted him by acclamation "Roman emperor!" and the Pope was the first who performed the old ceremony of adoration. Charles was now in reality master of the whole of the Western Empire, with the exception of the British Isles, and of Spain and Africa, which were in the possession of the Arabs. The territories he possessed in Germany, however—which had never owned the Roman sway—seemed to compensate for these exceptions. A war against the Saracens was a holy war, and his recognition as Roman emperor gave him an especial title to undertake it. The throne of Byzantium was at that time occupied by a woman, in circumstances which seemed to open up a still wider field for his ambition. After an interregnum of more than 300 years the Western Empire was re-established. The Bishop of Rome and the monarch of the Franks, each individually too weak for the task, had accomplished that between them. The former lent his spiritual influence, and the latter the physical force of his sword. The Pope anointed Charles, and Charles confirmed him as the head of the Wes ern churches. The object proposed was the attainment of the mastery of the world. The King of the Franks and the Bishop of Rome proposed to hold it *pro indiviso*, *i.e.* the one was to reign over men's souls, the other over men's bodies, and each was to make his peculiar power of avail to strengthen that of the other. The arm of flesh soon gave way. The warlike "Carolus Augustus, emperor of the Romans," died 28th January, 814, and was buried in the Minster of Aix-la-Chapelle, which he had founded, and was succeeded by his only surviving son, Louis le Debonnaire. The empire did not remain above 100 years in the possession of the descendants of Charlemagne. But the spiritual arm prospered, and seemed for a while even to grow stronger by being severed from its secular ally.

GEOGRAPHY.—CHAPTER X.

AFRICA: ITS POLITICAL DIVISIONS—THE POSSESSIONS OF BRITAIN, FRANCE, SPAIN, GERMANY, ITALY, TURKEY, &c.—SOVEREIGN AND FREE STATES.

In no portion of the habitable globe more than in Africa is the fact observable that geographical forms, peculiarities of physical structure, the sizes and disposition of defined regions, climate, and many other characteristics of the horizontal and vertical organization of land-surfaces, exert great influence upon the races which occupy the different portions of the earth, form the nations within their bounds, and engage in the activities which employ and develop the common life of humanity. The uniform coast outline, the land-locked interior, and the isolation tending to desolation, with want of community of purpose and interest, and of the emulative rivalry of individuals, tribes, nations, &c., are closely related as condition and result. Along the valley of the Nile and northern districts which margin the readily navigated Mediterranean, Africa has been stimulated into taking a share in the developing enterprise of civilized nations, and the commerce, intercourse, warfare, and changes which stir man and constitute history. Egypt, age-gray in mysterious civilization, and Carthage—which, as a maritime state, with a magnificent city, a haughty, arrogant, and active people, pursuing commerce, not with sails and merchandise alone, but by sword and intrigues, formed for a time a spur to Roman energy, and no mean compeer for it in war—show clearly that outlet and communication are large factors in historical development. At the same time the condition of unprogressive barbarism in which lay the long peninsular expanse lying under the tropical sun, and surrounded by what was then indeed "the dissociating ocean," proves equally conclusively that want of accessibility and intercourse cramps energy, corrupts morals, and occasions a deadly stagnation of human faculty. It is only of late, therefore, and, as communities born as it were out of due season, that Central and Southern Africa have been brought, with any effective power, within the range of those civilizing purposes which "through the ages run." In such wise do the influences of physiographical configuration influence and affect human character, and thus it is that the

EUROPE UNDER THE EMPIRE OF CHARLEMAGNE.

EUROPE AT THE DISMEMBERMENT OF THE CARLOVINGIAN EMPIRE

solid, little-broken-up land-mass of Africa, with its few sea-reaching, navigable rivers, is rightly described in reference to civilization as the Dark Continent.

The following table contains a list of the present political divisions of the African continent, together with statistics of their area and population, in most cases mere approximations:—

Political Division.	Area in Sq. Miles.	Population.
INDEPENDENT STATES—		
Morocco,	219,000	5,000,000
Abyssinia,	150,000	3,500,000
Liberia,	35,000	2,000,000
Congo State,[1]	900,000	30,000,000
Total Independent,	1,304,000	40,500,000
TURKISH POSSESSIONS—		
Egypt,[2]	400,000	9,750,000
Egyptian Sudan,[3]	950,000	10,000,000
Tripoli,	400,000	1,300,000
Total Turkish,	1,750,000	21,050,000
BRITISH POSSESSIONS—		
Nigeria,	500,000	30,000,000
Lagos (with Protectorate),	22,000	3,000,000
Gold Coast (with Protectorate),	60,000	4,500,000
Sierra Leone,	4,000	80,000
Gambia (with Protectorate),	3,000	200,000
Somaliland,	68,000	100,000
British East Africa (E. Africa, Uganda, and Zanzibar Protectorates),	1,000,000	6,000,000
Central Africa Protectorate,	42,000	1,000,000
Rhodesia,	400,000	800,000
Transvaal Colony,[4]	120,000	1,000,000
Orange River Colony,[4]	50,000	200,000
Cape Colony,	280,000	1,800,000
Basutoland,	10,000	250,000
Bechuanaland Protectorate,	213,000	200,000
Natal,	35,000	900,000
Mauritius and Dependencies,	800	400,000
Ascension Island,	35	430
St. Helena,	47	4,000
Socotra,	1,400	12,000
Total British,	2,809,282	50,446,430
FRENCH POSSESSIONS—		
Algeria (with Algerian Sahara),	308,000	4,500,000
Tunis,	50,000	1,500,000
Sahara Region,	1,700,000	2,500,000
Senegal,	200,000	3,500,000
Military Territories,	700,000	4,000,000
French Guinea,	95,000	2,200,000
Ivory Coast,	125,000	2,500,000
Dahomey,	60,000	1,000,000
French Congo,	450,000	8,000,000
Somali Coast Protectorate,	45,000	200,000
Madagascar,	227,750	2,500,000
Réunion,	970	173,200
Comoro Islands,	620	53,000
Mayotte,	140	11,640
Nossi-Bé,	130	9,500
Sainte-Marie,	64	7,670
Total French,	3,962,674	32,655,010
GERMAN POSSESSIONS—		
Kamerun,	191,000	3,500,000
Togoland,	33,000	2,500,000
German East Africa,	384,000	8,000,000
German South-west Africa,	322,500	200,000
Total German,	930,500	14,200,000
ITALIAN POSSESSIONS—		
Eritrea,	88,500	450,000
Italian Somaliland,	100,000	400,000
Total Italian,	188,500	850,000
PORTUGUESE POSSESSIONS—		
Portuguese Guinea,	4,440	820,000
Portuguese West Africa,	485,000	4,120,000
Portuguese East Africa,	300,000	3,120,000
Cape Verde Islands,	1,480	114,130
Prince's and St. Thomas' Islands,	360	24,660
Total Portuguese,	791,280	8,198,790
SPANISH POSSESSIONS—		
Rio de Oro, Ifni, &c.,	243,000	106,000
Canary Islands,	2,800	334,500
Fernando Po, and other Islands,	850	30,000
Total Spanish,	246,650	470,500

[1] Not strictly an independent state; now practically Belgian.
[2] Only nominally Turkish, but under the control of British officials.
[3] Practically not Turkish at all; under Anglo-Egyptian rule.
[4] Till 1900 recognized as independent republics, but in that year annexed by proclamation. The annexation has not yet been accepted by the Boer governments or peoples.

ABYSSINIA consists of a series of terraced plateaus, averaging in elevation from 5000 to 8000 feet, out of which there rise mountain groups and ranges. Between these highlands and the Red Sea, a flat tract called Adal extends along the coast. The river Hawash or Habesh rises in the south and flows eastward into the salt lake Assal, several hundred feet below the level of the Red Sea, in the Adal tract. In the same highlands the Abaie (Bahr-el-Azrek), an affluent of the Blue Nile; the Atbara (Bahr-el-Aswad or Black River); the Goang, a tributary, if not the direct source of the Atbara; the Takazze, a confluent of the Atbara, and many other rivers, rise. Towards the Nile the land slopes gently. In these highlands the climate is temperate and wholesome, but in the lowlands and along the coast it is exceedingly unhealthy. The people are "men of stature," round-faced, olive-complexioned, thick-lipped, short-nosed, with clear deep-set eyes. The political divisions of Abyssinia are unsettled. The more important subdivisions are (1) *Tigré*, of which the chief towns are Antalo and Adowa; (2) *Gondar* or *Amhara*, having its capital (of the same name) in the north-east of the plain of Dembea; (3) *Shoa*, south of Amhara, its capital, Adis Abbeba, being now practically the capital of the kingdom.

NUBIA is bounded east by the Arabian Sea, north by Egypt, south by Abyssinia, and west by the Sahara. It is divided into (1) *Lower Nubia*, the surface of which is generally a level, rocky, and sandy desert, except where it is watered by the Nile; (2) *Upper Nubia*, more undulating, better watered, and therefore more fertile. It was annexed to Egypt by Mehemet Ali in 1820. Nubia, Sennaar, Kordofan, Darfur, and other districts were for a time independent under the Mahdi, and his successor, the Khalifa; but in 1898 they were reconquered by an Anglo-Egyptian force, and they now form the Egyptian Sudan. The chief town is Khartoum.

EGYPT is nominally a province of the Ottoman Empire, and yet is independent under a ruler holding an old regal title, the Khedive, who supplies an annual tribute to the superior state. A strip of land, 10 miles in width, along the banks of the Nile, is under culture. When it reaches the Delta a larger expanse is cultivable, and the triangle itself is a great rice area. On the east the Nile is hemmed in by granite mountains, and on the west by limestone hill-ranges, behind each of which there are desert tracts. Wheat and barley grow along the main course of the river, millet (durra) is raised on grounds not favoured by the inundation. Cotton and sugar-cane are also extensively grown. Cairo, 25 miles above the point of the Delta, is the largest city in Africa. By river and canal, it communicates with the three ports—Alexandria, Rosetta, and Damietta, through the first of which the whole traffic between Europe and Egypt passes. Siout, in Upper Egypt, is a caravan rendezvous; so also is Keneh. Nearly opposite Keneh is Denderah—full of ruins of Egyptian art. Above Keneh is Thebes—with the ruins of Carnac and Luxor. Near the Nubian frontier is Assouan, where were the quarries of syenite, used in ancient Egyptian buildings, and opposite to it is the island of Elephantine, where there are remains of Roman, Saracenic, and Arabian, as well as native architecture. The Isthmus of Suez has been cut by a canal for the conveyance of European vessels to the East, which has become the waterway to India. Seven-eighths of the population of Egypt are Arabs, and they, like the Turks, are Mohammedans. The Christians are Copts, descendants of the ancient inhabitants, and are most numerous in the district of Faioum in Upper Egypt.

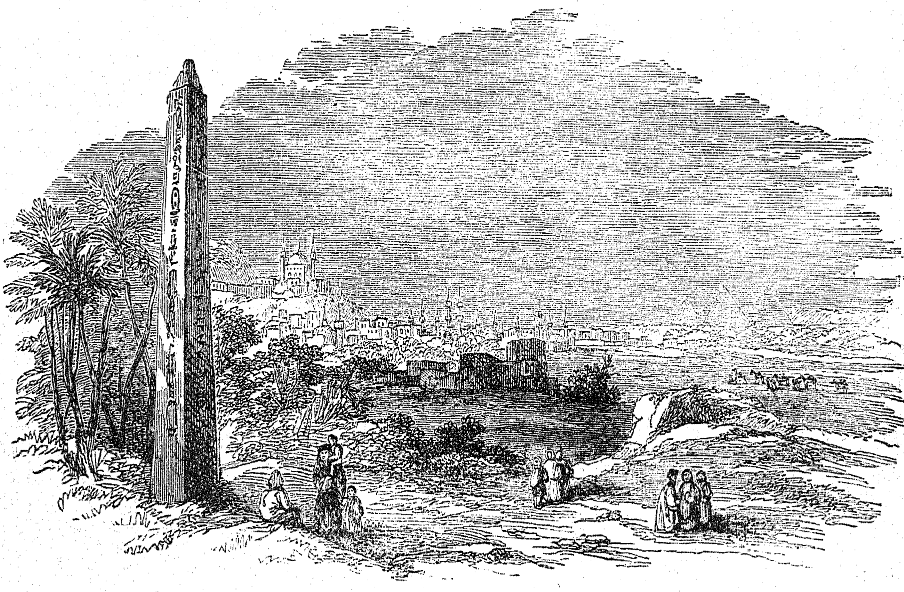
The *Barbary* states include Tripoli, Tunis, Algeria, and Morocco. In the first, while the shore is exceedingly fertile, the desert has been gradually narrowing the cultivable strip of the coast-line. There are no rivers in this vilayet (regency) of the Turkish dominion, which includes Fezzan and Barca, and rain seldom falls in it. Its capital, Tripoli, is a fortified seaport.

TUNIS is now under the rule of a Bey, nominally subject to Turkey, but really an informally constituted dependency of France. It is inhabited by a mixed race of Moors, Turks, and Arabs. Its mountains abound in silver, copper, and lead. It exports grain, oil, wool, esparto grass, leather, feathers, gold dust, &c. Shawls, carpets, mantles, fez-caps,

bernous, and perfumery are among its manufactures, besides silks and woollens. Its chief town, Tunis—a fortified city on the west side of the Gulf of Tunis—has the largest trade of any place in Barbary. Kairwan, with the most magnificent mosque in Barbary, containing the tomb of Mohammed's barber, lies south-east of Tunis, and is the centre of the inland trade.

ALGERIA—the native land of the merino sheep—is divided into three regions: (1) a narrow, fertile plain, on the coast; (2) a hilly plateau of the Atlas, rising in successive stages parallel with the coast, both designated the *Tell* (fertile part); as well as (3) the southern slope of the Atlas, an arid region, in which there are salt-marshes and salt-pans. This portion is occupied by a handsome hardy race of nomadic tribes called Kabyles. Algeria is a French possession, under a governor-general. Its mineral wealth is great. Mines of iron, copper, lead, quicksilver, &c., are worked in it. Its exports are live stock, cereal grain, fruits, vegetables, tobacco, raw silk, esparto grass, coral, sponges, &c. Frenchmen, Spaniards, and other Europeans constitute a considerable portion of the population. Algiers, its capital, is a strongly fortified seaport.

MOROCCO is an empire consisting of the two kingdoms of Fez and Morocco, north of the Atlas, and several territories—Sus, Draa, Wady Tafilet, Tuat, &c.—on the south. Over these the Emperor is absolute, though often the *Kadis* pay little heed to his sovereignty. Morocco has three capitals: (1) Fez, the chief residence of the sultan, in a pleasant valley 80 miles east of Tangiers; (2) Morocco, the ancient metropolis, in the south-east of the country; and (3) Megumez, 38 miles south-west of the town of Fez. Among the national industries are cattle-rearing and agriculture. Mineral treasures abound—antimony, gold, lead, silver, tin, rock-salt, &c. Its chief ports are Tetuan, off the Straits of Gibraltar (fortified); Tangiers, a few miles east of Cape Spartel; Rabat, 135 miles S.S.W. of the mouth of the Straits of Gibraltar; Saffi 95 miles, and Mogador 105 miles, on the Atlantic coast, west of Morocco. Ceuta, opposite Gibraltar, is the chief of four military stations held by Spain on the North African coast.



Cairo and the Pyramids.

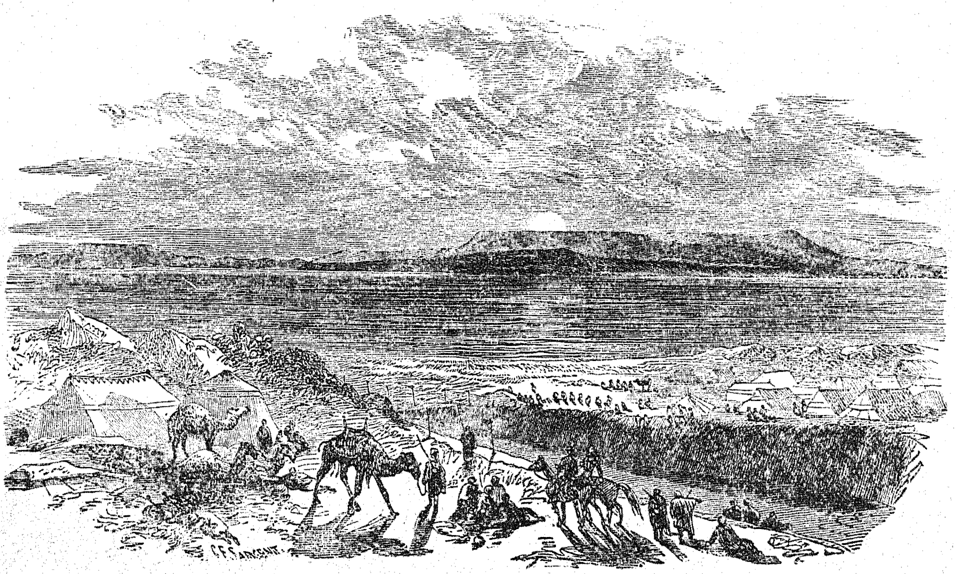
The SAHARA is an immense tract of territory, extending from the western border of the Nile Valley to within a very little of the Atlantic Ocean—2000 miles. Its surface is in large part overlaid with fine shifting sand, which the wind lifts and carries—often in overwhelming whirls—through the air. Over much of it rain never falls, and anywhere it is rare. Where the surface is not sandy, sandstone, granite, and quartz, rising sometimes into hills and ridges, are interspersed here and there with patches bearing coarse grass and low bushes, forming a dreary expanse, the oases in which only intensify the sense of the surrounding sterility. The oases are held by the powerful clans of the Muggrebi Arabs, who feed and furnish camels for the caravans which cross these arid regions with merchandise. Spain owns a portion of the Western Sahara, but the greater part of this desert region lies within the French sphere of influence.

Spain's possessions in Africa are few. Ceuta and a few small towns (*presidios*) in Morocco; Rio de Oro and Ifni on the Atlantic border; the islands of Fernando Po and Annobon, in the Gulf of Guinea; and the coast around Corisco Bay, exhaust the list of her African possessions. The Canary Islands are usually treated of in connection with European Spain.

The portion of the west coast between the river Senegal and the British colony of Gambia, together with a large inland area, forms the French colony of *Senegal.* The coast region is low-lying and unhealthy, but the interior is mountainous and much of it very fertile, and the river Senegal forms an excellent navigable water-way for hundreds of miles. Millet, maize, rice, gums, earth-nuts, castor-beans, coco-nuts, rubber, and kola are among the vegetable products; and cattle, sheep, goats, and camels are reared. Some minerals, including gold, silver, copper, and quicksilver, have been discovered. The largest town is St. Louis, on one of the mouths of the Senegal. The chief inland station is Kayes, on the Senegal, from which a railway is being made to the Niger. The colony is under a civil governor. The British Crown Colony of *Gambia* occupies a narrow strip along both banks of the lower part of the river Gambia, which is navigable for a considerable distance. The colony was really founded in the seventeenth century, but it has taken its present form only in the nineteenth century, and it has been a separate Crown Colony only since 1888. Its products are much the same as those of Senegal. The capital is Bathurst, on St. Mary's Island, in the Gambia estuary. A narrow strip of French territory intervenes between Gambia and *Portuguese Guinea.* This small colony extends from the river Caches to the Rio Grande, and includes the Bissagos Archipelago. The capital, Bolama, is situated on an island of this archipelago, and Bissau is the chief port. The chief products are rubber, wax, oil-seeds, ivory, and hides. To Portugal also belong the *Cape Verde Islands,* a volcanic group situated about 300 miles west of Cape Verde, with a rather unhealthy, tropical climate.

To the south-east of Portuguese Guinea lies *French Guinea,* formerly known as Rivières du Sud. This division extends inland to the fertile mountainous region known as Futa

Jallon, where agriculture and cattle-rearing are carried on. The capital is Konakry, on the coast, from which a railway is being constructed to the Niger. Next in order comes the British Crown Colony of *Sierra Leone,* extending from the Scarcies river on the north to Liberia on the south. It is watered by several navigable rivers, and produces palm-oil, palm-kernels, benni seed, ground-nuts, kola-nuts, rubber, hides, and other such commodities. In 1896 a protectorate was declared over a considerable area behind the colony. The capital, Freetown, on the coast, is an important seaport and the head-quarters of the British military forces in West Africa. It has a splendid fortified harbour, and is used as a coaling-station. To Sierra Leone belong Sherbro, the Los, and other islands. The negro republic of *Liberia,* founded in 1822 by some American and other philanthropists to make provision for freed negro slaves, was constituted as an independent state on its present basis in 1847. The constitution is modelled upon that of the United States, and no white man can become a citizen of the republic. The territory of the state extends from the Manah to the Cavally river, the coast being, as usual in West Africa, low and unhealthy, though inland the country is very fertile and much better in every way. Liberian coffee is well-known, and among other products of the country are palm-oil, palm-kernels, rubber, cocoa, sugar, arrowroot, ivory, hides, and piassava. The capital is Monrovia, on the coast. From the mouth of the Cavally to a point east of the Niger delta the trend of the coast is east and west. The French region known as the *Ivory Coast* follows Liberia immediately on the east, and extends north to the Military Territories. The capital is Grand Bassam, on a coast lagoon which forms a good harbour of refuge. East of the Ivory Coast is the British Crown Colony of the *Gold Coast,* with the extensive hinterland of Ashanti, formerly an independent kingdom in which horrible human sacrifices were of constant occurrence. Gold



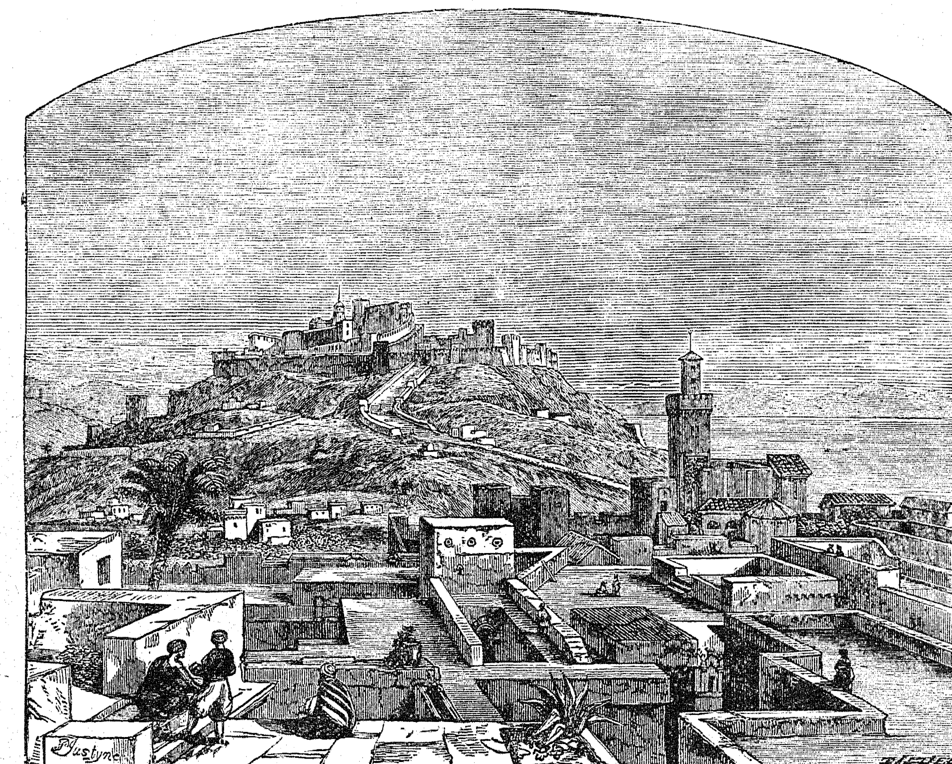
Suez Canal and Lake Timsi.

is found here in greater abundance than elsewhere in West Africa, and it is now being worked. The other natural products include palm-oil, palm-kernels, rubber, and valuable woods. The capital of the colony proper is Accra, and other coast towns are Elmina and Cape Coast Castle. The capital of the former kingdom was Kumasi, an inland town near the river Prah, which has been thrice visited by a British military expedition. A British resident is now stationed there. The lower course of the river Volta is entirely in British territory, but in its upper course it separates Ashanti from the German colony of *Togoland.* This colony, formed in 1884, was one of the earliest to be acquired of the foreign possessions of the German Empire. It has a coast-line of little more than 30 miles, but inland it widens greatly. The coast towns are Lome (the chief port and capital), Bagida, Porto Seguro, and Little Popo; and among inland government stations are Misahöhe and Bismarckburg. Its chief products are maize, yams, tapioca, ginger, bananas, cocoa, palm-oil, rubber, dye-woods, gums, coffee, &c.

Togoland is bounded on the east by *Dahomey,* formerly an independent kingdom, but since 1894 a French protectorate. Prior to the French conquest Dahomey was the scene of barbarous practices even more revolting than those which disgraced the Ashanti kingdom. Maize, manioc, yams, and potatoes are grown by the natives, and the forests contain baobabs, coco-nut palms, oil palms, and other useful trees. The capital is Porto Novo, on a coast lagoon, but the capital of the former kingdom was Abomey, an inland town. Other coast towns are Whydah, Grand Popo, and Kotonu, and among inland places are Allada, Agoue, Nikki, Carnotville, and Say, the last-named being on the Niger. The British Crown Colony of *Lagos,* with the Yorubaland protectorate, adjoins Dahomey on the east. This colony, situated along the shore of the Bight of Benin, exports palm-oil, palm-kernels, ivory, gums, cotton, rubber, cocoa, and coffee, and contains the important seaport of Lagos, on a long narrow island. It is low and unhealthy near the coast, but the more inland portions, constituting the former Yoruba kingdom, are mountainous and more favourable to Europeans. The Yorubas are a skilful and industrious race, amongst whom missionary effort has been fairly successful. Their chief towns are Oyo, Ibadan, and Abeokuta, the two latter of which are connected with Lagos by a railway. Lagos is bounded on the north and east by an extensive British region known since 1900 as *Nigeria,* and divided for administrative purposes into the two portions, Northern and Southern Nigeria. On the west Nigeria is bounded by Lagos, Yorubaland, Dahomey, and the French Military Territories; on the north, by the French region; on the north-east, by Lake Chad; and on the east, by the German Kamerun. It includes the whole course of the river Niger from about Ilo to its mouths, and also the whole course of the navigable Benue from above Yola to its junction with the Niger. Northern Nigeria comprises the extensive area of the former Sokoto empire, a portion of the former Borgu confederation, and most of the territory of the kingdom of Bornu; and to Southern Nigeria belongs the Benin region, annexed in 1897. There are numerous large and important towns in both divisions, but especially in Northern Nigeria. Asaba, Onicha, and Idda are the chief inland towns of the southern district, and among its

ports are Akassa, Bonny, New and Old Calabar, Brass, and Opobo. In Northern Nigeria the most important towns are Lokoja, at the junction of the Niger and Benue, Kano, Bida, Ilorin, Yakoba, Yola, Kuka, Wurno, and Gando. Silver, tin, and other metals have been discovered in the north, and this part of the country is also well adapted for agriculture. A valued kind of leather is manufactured by the natives.

The German colony of *Kamerun* has its coast-line on the Bight of Biafra, where the coast begins to have a southerly trend. It extends inland to Lake Chad, and is bounded on the north-west by Nigeria, on the east and south by French Congo. The coastal district has an exceedingly fertile soil of volcanic origin, on which the Germans cultivate cacao, coffee, and tobacco with success. Inland there are the lofty Kamerun mountains, and the plains of the interior are said to be admirably adapted for cattle-rearing. The rivers, of which the chief are the Rio del Rey (boundary), the Kamerun, the Sannaga, and the Campo (boundary), are impeded by cataracts. The chief town is Kamerun, on the coast. The climate is less unhealthy than that of most of West Africa. To the south of Kamerun lies the coastal portion of *French Congo*, which extends north-east to Lake Chad and the Bahr-el-Ghazal valley in the Egyptian Sudan. This immense region is bounded on the south and east by the river Congo and its great tributary the Ubangi, but a strip along the north bank of the lowermost portion of the Congo belongs to the Congo Free State and to Portugal. Spain, which possesses some islands off the coast, also owns a small



Tangiers.

enclave on the north coast of French Congo. Besides the rivers already mentioned there are others, chiefly the Ogowé and the Gaboon. The country is known to possess much mineral and vegetable wealth, but its resources have been but little exploited or explored as yet. The capital is Libreville, on the Gaboon estuary, and other towns are Loango, on the coast, Franceville and Brazzaville, on the Congo. The immense inland possessions of France enclose all the coast territories from Cape Verde to the Congo. An important part of these possessions not already described is the region known as the *Military Territories.* They include the country within the great Niger bend, north of the Ivory Coast, Ashanti, Togoland, and Dahomey, and extend eastwards beyond Lake Chad to the Egyptian Sudan. The chief town is the famous Timbuktu, an important trading centre on the river Niger. The *Congo Free State* is mainly an inland state, but to it belong both banks of the lower Congo. It was founded by international arrangement soon after the famous journeys of exploration by which Sir Henry Morton Stanley revealed to the world the course of the Congo river and the nature of the countries watered by it. It was formally constituted in 1885, under the sovereignty of the King of the Belgians, and Belgium now has the power of annexing it if she so desires. Its administration has latterly been stained by much cruelty and oppression. On the north the Ubangi river separates it from French Congo, and on the west the Ubangi and the Congo separate it from the same region. On the south-west it is bounded by Portuguese West Africa; on the south by Rhodesia; on the east by Lake Tanganyika, German East Africa, and Uganda; and on the north-east by the Egyptian Sudan. Its chief natural features are the Congo and its numerous affluents, and the large lakes on its frontiers. Its products comprise rubber, ivory, palm-nuts, palm-oil, coffee, cocoa, and tobacco. The chief ports are Boma, the capital, and Banana.

Between the mouth of the Congo on the north and the lower Cunene on the south there lies *Portuguese West Africa* or Angola, with S. Paulo de Loanda as capital, and Benguela and Mossamedes as other ports. The small enclave of Cabinda, on the north side of the Congo, is included in Angola. Copper, iron, petroleum, and salt are the most abundant minerals, and the vegetable products are similar to those often mentioned above. On the east coast Portugal possesses an extensive territory known as *Portuguese East Africa,* extending from the mouth of the Rovuma river south to Zululand, and bounded by German East Africa, Lake Nyassa, British Central Africa, Rhodesia, and the Transvaal. Gold is mined on the borders of Rhodesia. Railways now proceed inland from Delagoa Bay (Lorenzo Marques) and Beira. Other ports are Mozambique, Quilimane, Inhambane, and Chinde. *German South-west Africa,* between the Cunene and the Orange rivers, includes Damara-

land and Great Namaqualand, but Walvisch Bay, the only good port on its coast, belongs to Britain. Great Windhoek is the capital. Cattle, sheep, and goats are reared in large numbers, and copper and gold have been found. *German East Africa* lies to the north of Portuguese East Africa and includes part of the great lake Victoria Nyanza, and also the lofty peak of Kilimanjaro. Its mineral and vegetable wealth is being vigorously exploited. Its chief ports are Dar-es-Salaam, Bagamoyo, Quiloa, and Tanga. *British East Africa* in the widest sense includes: (1) the Zanzibar Protectorate, comprising the islands of Zanzibar and Pemba; (2) the East Africa Protectorate; and (3) the Uganda Protectorate, to the north and west of Victoria Nyanza. Mombasa is the capital of the East Africa Protectorate, and from this town a railway is being constructed to Victoria Nyanza. The trade of this region is largely in the hands of East Indian merchants. Mt. Kenia and other lofty peaks, Lake Rudolf and other smaller lakes, are among its more notable natural features. Uganda promises well in respect both of minerals and of fertility, and on its frontiers the new ruminant allied to the giraffe, the okapi, was recently discovered by Sir H. H. Johnston. Italy owns a strip of coast (*Italian Somaliland*) extending north from British East Africa, and Britain possesses a strip along the Gulf of Aden, with the ports of Berbera, Zeila, and Bulhar (*British Somaliland*). On the west coast of the Red Sea there are *Obok*, belonging to France, and *Eritrea*, an Italian possession, with Massowah as its chief port.

The British Empire in South Africa covers an area of more than 1,000,000 square miles. It consists of Cape Colony, Natal, Basutoland, Bechuanaland, Rhodesia, Central Africa Protectorate, Transvaal, and Orange River Colony. Cape Colony derives its name from the Cape of Good Hope. Its coast of 1200 miles is washed by the Atlantic and the Indian Ocean, while its northern boundaries have the waters of the Orange or Gariep, the Indwa, and the Kei, flowing along them. The territories lying between the Kei and Natal are called the Transkeian territories. There is also the port of St. John's, Walvisch Bay, surrounded by German territory, and Griqualand West, with the great diamond-mining centre of Kimberley.

The Cape Colony is under the responsible government of His Majesty's High Commissioner for South Africa, assisted by an executive, a legislative council, and a house of assembly. The capital is Capetown. Other chief towns are Grahamstown, Port Elizabeth, and Kimberley. The colony is almost destitute of natural harbours, and vast expense has been incurred in erecting protective works at its several ports.

Natal, discovered by Vasco da Gama on Christmas Day, 1497, lies on the south-east coast, and is separated from Cape Colony by the Drakensberg Mountains. It has only the single harbour of Port Natal or Durban on its seaboard. No fewer than twenty-three rivers flow through Natal into the Indian Ocean, yet no one of them is navigable. The mountain regions abound in forests of valuable timber. In the uplands sheep-farming and grazing prevail. European crops thrive in the midlands, and in a tract of 15 miles' width along the coast tropical fruits and plants prosper, and yet the climate is quite favourable to European health. It is ruled under a governor, assisted by an executive and a legislative council and legislative assembly, elected by the colonists. The capital and seat of government is Pietermaritzburg. Zululand was annexed to Natal in 1897.

British Bechuanaland, which lies north of Cape Colony and south of the Molopo river, was, up to 1895, a Crown colony, and the territories of the chiefs Khama, Sebele, and Bathoen are still directly administered by an imperial officer. The rest of the territory is under the administration of the South Africa Company, except a strip which adjoins the Transvaal, and through which a railway from Cape Colony has been constructed. The vast territory (Rhodesia) now administered by the British South Africa Company includes the whole of the region lying north of the Transvaal, east of the German possessions on the west coast, and west of the Portuguese province on the east coast. It is still chiefly in native occupation. The British Central Africa Protectorate lies along the west and south shores of Lake Nyassa.

The Orange River Colony was till the annexation of 1900 a republic under the name of Orange Free State. It was founded by Boer or Dutch emigrants from Cape Colony. It is mainly a pastoral country, though in the east it seems admirably fitted for grain culture. Rich coal mines exist in it, and its hill-lands yield various precious stones. These, along with wool, hides, and ostrich-feathers, form its chief exports. The capital is Bloemfontein.

The Transvaal Colony is bounded on the south by the Vaal river and on the north by the Limpopo. Till 1900 it was an independent republic (South African Republic), but after the occupation of the capital by British troops in the course of the South African War of 1899–1902 it was annexed by proclamation to the British Empire. The republican government and the vast majority of its people still refuse to accept the annexation. The colony contains the richest gold-fields in the world, besides other mineral wealth. Its capital is Pretoria, and its most important mercantile centre is Johannesburg.

France in 1895 practically annexed Madagascar, the largest of the islands of Africa, which is surrounded by the Indian Ocean, and is separated from the mainland by the Channel of Mozambique. The islands of Réunion (Bourbon), Comoro, Mayotte, &c., belonging to France, and Mauritius, the Seychelles, Rodriguez, Diego Garcia, &c., belonging to Britain, all in the Indian Ocean, should also be mentioned.

THE FRENCH LANGUAGE.—CHAPTER XI.

PREPOSITIONS: THEIR NATURE, USES, CLASSES, AND PECULIARITIES—SYNTAX—ANALYSIS OF SENTENCES—FORMATION OF SENTENCES—PRACTICAL EXERCISES IN WRITING, SPEAKING, AND READING.

We have in our previous lessons explained pretty fully the various changes which may be made in words by inflexion. We required to do so because, without an adequate knowledge of these changes, the structure of sentences could not be rightly understood; nor could the proper value be attached to the changing forms of words employed in conversation or in composition. The student is now, however, furnished with a sufficient amount of information regarding the possible inflexions of French vocables, and has the opportunity of readily referring to the matter of the previous lessons for the solution of any difficulty he may experience, so that he should be able to engage profitably in considering the construction of sentences and in learning to employ the knowledge he has gained in the practical use of the language. It is true that we have not yet supplied a complete survey of all the parts of speech. Those which remain to be spoken of are, however, invariable in their forms, and do not require to be pursued, as it were, through the Protean appearances which those classes of words already treated of assume, often so puzzlingly. As a matter of practical convenience therefore we shall now take up only one part of speech in each succeeding lesson, and devote a considerable amount of our space to the explanation of sentence-building and the suggestion of means by a patient and attentive use of which a ready power of writing and speaking French may be simply yet surely acquired.

In this chapter we shall first define the nature of prepositions, explain their uses, specify the most important of them, and shall thereafter pass on to lay before the student such statements regarding systematic syntax, and such exemplifications of its laws, as shall guide him in his endeavours to frame his sentences on Parisian models, and to express his ideas in the forms of speech peculiar to the people of France.

SECTION I.—PREPOSITIONS AND PREPOSITIONAL PHRASES.

A preposition is an invariable, *i.e.* an uninflected, word, which, taken alone, suggests no complete sense, but which, when placed before nouns or verbs, indicates some relations between them and some preceding word or words, to which the preposition and the noun or verb governed by it form a

complement; as in the sentences, *Je vais à Paris*, I go to Paris; *Je suis dans le jardin*, I am in the garden; *Le livre de mon oncle est sur la table dans le salon*, The book of (*i.e.* belonging to) my uncle is upon the table in the drawing-room.

Certain combinations of words have, by long usage, come to have a prepositional force, and are now generally regarded as prepositions, and are included in the lists given by French grammarians.

Those prepositions which consist of a single word are called *simple;* as *de*, of; *avec*, with; *sans*, without; *dans*, in, &c. Those which are formed by a combination of words are by some called *compound* prepositions, and by others prepositional phrases; such are *au lieu de*, instead of; *en dépit de*, in spite of, &c.

With the single exception of *durant—e.g. sa vie durant*, during his life—all French prepositions, true to their name, are placed before the words which they govern, never after them. Though in English we can say, Whom do you reckon upon? we must in French say, Upon whom do you reckon?

As a general rule, the simple or primary prepositions require in French to be repeated before each word they govern, whether it be noun, pronoun, or verb; as *J'ai été vaincu par les ruses et par les armes de mes ennemis*, I have been overcome by the stratagems and by the arms of mine enemies.

The chief relations which prepositions express are those of (1) place, (2) order, (3) union, (4) separation or opposition, (5) aim or purpose, (6) means and cause. Some, however, are very general in their signification, and are exceedingly variable in their idiomatic force. Upon their proper use a thousand and one of the simple elegancies of French phrases depend, and grace of style demands the utmost attention to the peculiar constructions in which prepositions occur, as many of them imply peculiar delicacies and subtleties of meaning arising from usage and association.

The following include the more specific of the prepositions in the several classes:—

A,	*to, at.*	Hors,	*save.*
Après,	*after.*	Malgré,	*in spite of.*
Avant,	*before.*	Moyennant,	*by means of.*
Avec,	*with.*	Nonobstant,	*notwithstanding.*
Chez,	*at (the house of).*	Outre,	*besides.*
Contre,	*against.*	Par,	*by.*
Dans,	*in.*	Parmi,	*among.*
De,	*of, from.*	Pendant,	*during.*
Depuis,	*since, after.*	Pour,	*for, in order to.*
Derrière,	*behind.*	Sans,	*without.*
Devant,	*before.*	Selon,	*according to.*
Durant,	*during.*	Sous,	*under.*
En,	*in, into.*	Sur,	*on* or *upon.*
Entre,	*between.*	Touchant,	*concerning.*
Envers,	*towards.*	Vers,	*towards.*
Hormis,	*except.*		&c., &c.

The following observations point out some of the more specific peculiarities requiring to be attended to in the use of French prepositions. They will be found useful for reference either in reading, writing, or speaking:—

A, speaking generally, expresses destination, tendency, place, time, situation, &c., and is often used instead of other prepositions. *A* may be regarded as specially a dative preposition. Its primary meaning is "to," but it also frequently means at, in, from, by, &c. It is thus used to express the dative of (1) the recipient in reference to verbs of giving, telling, showing, &c., which take a direct objective of a thing and an indirect one of a person; as *Il donne une maison à son père*, He gives a house to his father; (2) advantage or disadvantage, likeness or unlikeness, superiority or inferiority, obedience or disobedience, trust or distrust, fitness or unfitness, pleasantness or unpleasantness, &c., indicated by nouns, adjectives, verbs, or adverbs; as *Propre à rien*, Fit for nothing; *Sa voix ressemble au tonnerre*, His voice resembles thunder; *Tout citoyen doit obéir aux lois*, Every citizen ought to obey the laws; (3) of possession, especially with the verb *être;* as *A qui est ce livre?* To whom does this book belong? *C'est à moi*, It belongs to me; (4) of a fixed point in space or time; as *Il sortit à huit heures du matin*, He went out at eight in the morning; *A dix pas d'ici*, At ten steps from here; (5) of tendency, course, destination, use, &c.; as *Jetez le chapeau à la mer*, Throw the hat into the sea; *Un pot au lait*, A milk-jug. *A* is also used to denote price, value, quantity; as *La viande se vend à la livre*, Meat is sold by the pound; *Il m'en a envoyé à foison*, He has sent me plenty of it.

Après, after, refers to time or place and succession of actions and objects; as *Après le dîner*, After dinner; *Je suis venu après vous*, I came after you.

A travers or *au travers de* is rendered by across or through. The latter is used where it is implied that effort is necessary or obstacles are overcome.

Au-dessous de, *au-dessus de*, are compound prepositions, and correspond to the English below and above.

Avant refers to time, *devant* to place; as *Je suis venu avant vous*, I came before you; *Je suis placé devant vous*, I am placed before you.

Avec, with, has two meanings: (1) along with, (2) the instrument by which, &c. When the agent is mentioned *avec* is preferable to *par*, by, by means of; as *Il est arrivé avec lui*, He came with him; *Il l'a tué avec son épée*, He has killed him with his sword.

Chez has no verbal equivalent in English. It is translated in various ways, but principally by at, at home, with, and amongst. The word "house" must often be added to render its meaning fully; as *Chez moi*, At my house; *Chez mon frère*, At my brother's [house]; *Chez lui c'est une habitude*, With him, it is a habit.

Dans, in, has a more precise meaning than *en;* it therefore is used before common nouns when they are preceded by any determinative word or expression. *En*, however, is used before dates.

De is in general used to express or imply separation, origin, possession, cause, result, &c., and is also used in place of many other prepositions; as *Je viens de France*, I come from France; *Le palais du roi*, The palace of the king; *Les facultés de l'âme*, The faculties of the soul; *Un homme d'esprit*, A man of wit; *Il est aimé de tout le monde*, He is beloved by everybody; *Mourir de faim*, *de soif*, &c., To die of hunger, thirst, &c.; *Vivre de fruits*, *sauter de joie*, &c., To live on fruits, to leap for joy, &c. The primary idea implied in *de* is from, and from that notion we deduce the cognate ideas, such as from, meaning distance in time and place; proceeding from origin and cause; made from (such and such) materials; derivation from, by birth, agency, operation; separation from, as a part from a whole, a person and his possessions, &c. It also implies the ideas of respect for, which separates one in thought from another and requires a difference of manner from that which we would use with an equal; of measure, or the taking of a part from the thing measured; of price, that for which we receive something from another; of comparison, by perception of that which distinguishes one from another, and so on—including all the ideas usually implied in the genitive and ablative cases of Latin nouns: (1) Origin, source, or material; as *Les grandes qualités du capitaine*, The great qualities of the captain; *Une montre d'or*, A gold watch. (2) Separation; as *Dehors de chez lui*, Away from home; *Il part de Paris*, He starts from Paris. (3) Nature, quality, possession; as *Le maître de la maison*, The master of the house; *Composé de plantes*, Composed of plants. (4) Partitiveness and negation, which is a partitive operation; as *Elle a infiniment d'ésprit*, She has an abundance of wit; *Il n'y a personne d'élu*, There is nobody elected; *Prenez de ces pommes*, Take some of these apples.

Depuis (before a noun) and *depuis que* (before a verb), since, from, is used for time, place, and has for its correlative *jusqu'à*, as far as; as *Depuis deux ans*, Two years since; *Depuis ici jusqu'à Rome*, From here to Rome.

Dessus, over, and *dessous*, under, are used as prepositions when both are used together; as *J'ai cherché dessus et dessous le lit*, I have looked on and under the bed.

Durant and *pendant* both mean during or for, but *pendant* is more definite; as *Sa vie durant*, During (the course of) his life; *Pendant cette nuit*, During this night.

En is used to mark the relations of time, place, situation, &c.; as *C'était en hiver*, It was in winter; *Être en Angleterre*, To be in England; *Aller en Italie*, To go to Italy; *Elle est en bonne santé*, She is in good health.

En is also used before dates, before disjunctive personal pronouns, and before indeterminate nouns. A noun is generally indeterminate when it is not preceded by either an article or a determinative adjective. *En* may be described as being less definite than *dans*, in, and is not used before an article, a possessive, a demonstrative, or an indefinite adjective; as *En voiture*, In a carriage; *Dans sa propre voiture*, In her own carriage.

Entre, between; *parmi* (a contraction of *par le milieu*), among. The former is generally only used of two objects, the latter with reference to several; as *Il y a procès entre ces deux hommes*, There is a lawsuit between these two men; *Il se mêla parmi la foule*, He mixed among the crowd.

Envers, as well as *vers*, means towards. *Vers*, towards, is used with reference to nouns which indicate place or time; as *Vers la porte*, Towards the door; *Vers le quatorzième siècle*, Towards the fourteenth century. *Envers* means with regard to, and is used after words implying behaviour; as *Agir bien envers quelqu'un*, To act well towards anyone.

Hors means except; *hors de*, out of, outside of; *dehors* is used in the same sense, but *en dehors de* is more common.

Jusque, as far as, is generally used with *à* (*jusqu'à*, to, even to, as far as, till). It occurs both with regard to place and time, and is the correlative of *depuis;* as *Depuis Paris jusqu'à Londres*, From Paris to London; *Depuis huit heures jusqu'à minuit*, From eight o'clock till twelve.

Pour, for, for the sake, for the purpose of, denotes the end, cause, intent, or reason for doing a thing; as *Cela est pour vous*, That is for you; *Je fais cela pour vous plaire*, I do that in order to please you. This preposition is very often used after *assez*, *trop*, *suffire*, *suffisant*.

Près de means near, of place or time; *auprès de* is only used of place; its most common uses are (1) attached to, in attendance upon, (2) beside, in comparison with; as *Je l'ai vu près du temple*, I have seen him near the temple.

Près and *proche* both mean near; the latter, however, only relates to space; as *Il est bien près de midi*, It is very near midday; *Il s'est allé loger proche du palais*, He has gone to live near the palace.

Selon, *suivant*, according to. The first is generally said of opinion, the second of practice; as *Chacun sera récompensé selon ses œuvres*, Each one shall be rewarded according to his works; *Il juge suivant les lois*, He judges according to law.

Sous, under, is used idiomatically in phrases like *Sous quinze jours*, In less than a fortnight; *Sous peu*, In a short time.

Sur, on, upon, has a great many meanings in French; as *Passer la main sur une étoffe*, To pass the hand over a stuff; *Ecrire sur du papier*, To write on paper; *Avoir une arme sur soi*, To have arms about or upon one. It primarily gives the idea of an object resting or placed upon another; as *Sur la table*, On the table. Figuratively it signifies superiority over, dependence upon, concerning; as *Cette nation a bien des avantages sur d'autres*, This nation has many advantages over others; *Je puis compter sur quelqu'un*, I can reckon on somebody.

Besides *à* and *de*, *pour*, *sans*, and *par* are those most frequently used before verbs in the infinitive. *En* takes the present participle after it; as *En passant*, In passing. *Après* is used before the auxiliaries *avoir* and *être*.

As it is not always easy to get readily, even with dictionary in hand, the special prepositional form we require or are in search of, with its usual idiomatic force as a part of speech, we subjoin a list of the most usual prepositions and prepositional phrases, with examples of their general use and signification. It ought to be repeatedly read, and consulted carefully while engaged in reading or in composition, &c.

Prepositional Phrases.

Il est à Londres,	*he is in London.*
A cause de maladie,	*on account of illness.*
A cause de vous,	*on account of you (on your account)*
A couvert de la neige,	*sheltered from the snow.*
A cause de lui,	*on account of him (on his account).*
A coté de son père,	*by the side of his father.*
A fleur d'eau,	*on the top of the water.*
A force de coups,	*by dint of blows.*
A l'abri de la pluie,	*sheltered from the rain.*
A l'égal des autres,	*on a par with the others.*
A l'égard de cette affaire,	*respecting that business.*
A l'insu de ses amis,	*unknown to his friends.*
A la mode de Paris,	*after the Parisian fashion.*
A raison de mille francs,	*at the rate of a thousand francs.*
Aller au devant de quelqu'un,	*to go to meet somebody.*
Au deçà de la haie,	*on this side of the hedge.*
Au dedans de l'église,	*inside the church.*
Au dehors de la salle,	*outside the room.*
Au devant du jardin,	*before the garden.*
Au lieu de pain,	*instead of bread.*
Au milieu de tant d'ennemis,	*in the midst of so many enemies.*
Au moyen d'argent,	*by means of money.*
Au niveau de la table,	*on a level with the table.*
Au prix de sa santé,	*at the cost of his health.*
Au rez de chaussée,	*even (or level) with the ground.*
Au risque de se noyer,	*at the risk of being drowned.*
Aux dépens de son repos,	*at the expense of his peace of mind.*
Aux environs du village,	*in the neighbourhood of the village.*
Il était percé à travers le corps,	*he was run through the body.*
Tout à fait comme sa mère,	*quite like his mother.*
Vis à vis de la bourse,	*opposite the exchange.*
Quant à celà,	*so far as regards that.*
A la hauteur du mur,	*at the height of the wall.*
Retirez le de dessous la table,	*draw it from under the table.*
Elle arrive de France,	*she comes from France.*
Faute de talents,	*for want of talent.*
Loin de la faire,	*far from doing it.*
Nous partirons après la fête,	*we shall set out after the holidays.*
Il l'a fait attendu sa promesse,	*he has done it according to his promise.*
Autour de la table,	*round the table.*
Ils sont partis avant vous,	*they have set out before you.*
Restez avec moi,	*remain with me.*
Entrez chez nous,	*come to our house.*
Mettez celà contre la porte,	*put that against the door.*
Demeurez dans la ville,	*remain in the town.*
Nous marchions derrière elle,	*we were walking behind her.*
Elle se tient devant lui,	*she stands before him.*
Il restera durant l'hiver,	*he will remain during the winter.*
Je sors en été,	*I go out in summer.*
En présence du juge,	*in the presence of the judge.*
Que celà reste entre vous et moi,	*let that rest between you and me.*
Elle se tourna envers ses amis,	*she turned towards her friends.*
Il y avait environ dix hommes,	*there were about ten men.*
Elle meprise tout excepté la science	*she despises all but science.*
Nous aimons tout hormis la science,	*we like all except science.*
Tout m'ennuie hors la science,	*everything wearies me except science.*
Il le maintient malgré tout le monde	*he maintains it in spite of everyone.*
Je dis qu'outre ce sujet,	*I say that besides that subject.*
Il sauta par la fenêtre,	*he jumped through the window.*
Il est passé par dessous le carrosse,	*he went under the coach.*
Arrangez celà par dessus la tête,	*set out that above the head.*
Celà est par deçà les Alpes,	*that is on this side the Alps.*
Nous le rejoignîmes par delà la rivière,	*we overtook him on the other side the river.*
Celà se fait parmi eux,	*that is practised among them.*
Elle dormit pendant la cérémonie,	*she slept during the ceremony.*
Je le ferai pour les frais,	*I shall do it for the expenses.*
Près (*or* proche) de la maison,	*near the house.*
Elle serait morte sauf son secours,	*she would have died but for his help.*
Il parla selon son avis,	*he spoke according to his advice.*
C'était sous la chaise,	*it was under the chair.*
Je me réglerai suivant ce qu'il fera,	*I shall determine according to what he will do.*
Mettez le sur la table,	*put it on the table.*
Nous parlions touchant l'ouvrage,	*we were speaking about the work.*
Nous arrivâmes vers la nuit,	*we arrived towards night.*
Par rapport à ceci,	*as for this.*
Je l'attends depuis Noël,	*I expected him since Christmas.*
Je lui pardonne vu son age,	*I pardon him on account of his age.*
Vous réussirez moyennant celà,	*you will succeed by means of that.*
Il voulut le faire nonobstant celà,	*he would do it notwithstanding that*
Il a résolu concernant l'affaire,	*he has determined respecting the business.*
Non pas sans raison,	*not without reason.*
Le long de la rivière,	*along the river.*
Auprès de la maison,	*quite close to the house.*
Jusqu'au parc,	*as far as the park.*
Pour l'amour de moi, de lui, &c.,	*for my, his, &c., sake.*

SECTION II.—SYSTEMATIC SYNTAX.

That we may be able to use a language in such a way as to read, write, and speak it readily, we require not only to know the vocabulary of the language—that is, the different words which it contains—so that the whole range of human experience may be expressed by it, and the various changes which its various vocables undergo, in order that the alterations in time, circumstance, desire, relation, connection, number, cause, &c., which occur within the range of experience may be indicated; but we must also learn the manner in which words are arranged and disposed, one in relation to another, in sentences by those who are most in the habit of using that language with propriety, elegance, and vivacity. The practice of reputable authors is a good guide in orthography, accidence, and syntax, and the usual habit of speech in refined and cultured circles of society forms the general standard of pronunciation and colloquial or idiomatic conversational correctness. The name given by grammarians to that part of their science which treats of the correct arrangement and coordination of the several parts of speech in the formation of sentences is syntax. It is the aim of grammarians, in drawing up the rules of syntax, to direct the learner aright in the difficult art of constructing sentences. Syntax requires that special attention be paid to two essential relations of words one to another—viz. (1) *concord*, or agreement, and (2) *government*, or the dependence of words for their order and relation on one another.

I. CONCORD requires the consistency of all the words employed in a sentence, one with another, in regard to number, gender, case, and all inflexional changes, so that they may each harmonize with the other and be susceptible only of one united signification. All difficulties regarding concord arise among those words which are variable, *i.e.* articles, adjectives (including participles), nouns, pronouns, and verbs. Words can only be put in proper concord when we know thoroughly the classes to which they belong, the functions performed by each class, and the modifications to which words of each class are subjected in the course of fulfilling their respective functions.

II. GOVERNMENT is that series of regulations which fixes the relation which words hold one to another, according to their place and power in each sentence, and the order which each word ought to occupy, so that it may be rightly placed in accordance with the French mode of idiomatic expression.

Although there are many minute rules necessary to be observed by all who would speak French with due attention to those delicate *nuances* and exquisitely varied shades of meaning which words in certain collocations bear, there are also some broad general principles which may be concisely stated, and the knowledge of which, if carefully borne in mind, will greatly aid us in the ordinary use of the language. The following, for instance, it will be useful to have fully fixed in the memory and regularly in our thoughts, as governing principles, while speaking—not consciously, but unconsciously, being conformed to by the culture of that habit which is second nature:—

In French a noun is seldom used in the beginning, or even in the middle of a sentence, without being preceded by an article or a pronoun.

After ascertaining the gender of a noun about to be used, be careful always to make any related article, adjective, and pronoun agree with it.

Articles and pronouns of every kind should, as a general rule, be repeated before every noun or verb.

Adjectives, in French, are generally placed *after* their substantives. Some give a different signification if they are used *before* instead of *after* a noun.

The verb must agree in number (and where necessary in gender) with its nominative, which it generally follows in order.

When two verbs come together (the one governed by the other) the second is put in the infinitive.

After any preposition, except *en*, the next verb is put in the infinitive; after *en* the present participle is used instead of the infinitive.

Along with an auxiliary verb use a past participle.

The personal pronouns *je, tu, il, elle, nous, vous, ils, elles, le, la, les, me, te, se, lui, leur, y, en*, must be placed before the verb, unless it is in the imperative or interrogative moods.

The arrangement of personal pronouns, when there are two or three governed by the same verb, is often a matter of much difficulty in the construction of French sentences by English students. The following table shows at a glance not only the relative position of the personal pronouns with regard to each other, but also with reference to the verb and other words connected with them in a sentence. The figures of course indicate the order of the words:—

1	2	3	4	5	6	7	8	9	10	11
Je	ne	me	le	lui	y	en	*auxiliary*	pas	*adverb*	*participle*
Tu	“	te	la	leur	“	“	or *verb*	“	“	“
Il	“	se	les	“	“	“	“	“	“	“
Elle	“	“	“	“	“	“	“	“	“	“
Nous	“	nous	“	“	“	“	“	“	“	“
Vous	“	vous	“	“	“	“	“	“	“	“
Ils	“	se	“	“	“	“	“	“	“	“
Elles	“	“	“	“	“	“	“	“	“	“

It is to be understood that although all the words numbered do not, and it may be cannot, come together in the same phrase, yet that as many as do occur invariably preserve the same relative position, as the examples given in the succeeding paragraph show—

1. ^{1}Je ^{4}le ^{8}crois. 2. ^{1}Je ^{2}ne ^{4}le ^{8}crois ^{9}pas. 3. ^{1}Il ^{3}me ^{8}voit. 4. ^{1}Il ^{2}ne ^{3}me ^{8}voit ^{9}pas. 5. ^{1}Tu ^{5}lui ^{8}parles. 6. ^{1}Tu ^{5}lui ^{8}as ^{11}parlé. 7. ^{1}Je ^{4}le ^{5}lui ^{8}dis. 8. ^{1}Je ^{2}ne ^{4}le ^{5}lui ^{8}ai ^{9}pas ^{10}encore ^{11}dit. 9. ^{1}Il ^{3}me ^{4}les ^{8}a ^{11}donnés. 10. ^{1}Il ^{2}ne ^{3}me ^{4}les ^{8}a ^{9}pas ^{10}encore ^{11}donnés. 11. ^{1}Nous ^{2}ne ^{5}lui ^{8}avons ^{9}pas ^{10}encore ^{11}écrit. 12. ^{1}Ils ^{5}lui ^{7}en ^{8}ont ^{11}envoyé. 13. ^{1}Je ^{2}n'^{6}y ^{8}suis ^{9}pas ^{11}connu. 14. ^{1}Il ^{2}n'^{6}y ^{8}est ^{9}pas ^{11}arrivé. 15. ^{1}Ils ^{2}ne ^{3}vous ^{7}en ^{8}ont ^{9}pas ^{11}demandé. 16. ^{1}Nous ^{2}ne ^{3}vous ^{7}en ^{8}avons ^{9}pas ^{11}envoyé. 17. ^{1}Ils ^{2}ne ^{3}s'^{6}y ^{8}sont ^{9}pas ^{11}appliqués. 18. ^{1}Vous ^{2}ne ^{3}vous ^{7}en ^{8}êtes ^{9}pas ^{10}encore ^{11}plaint.

1. I believe it. 2. I do not believe it. 3. He sees me. 4. He does not see me. 5. Thou speakest to him. 6. Thou hast spoken to him. 7. I told it to him. 8. I have not yet said it to him. 9. He gave them to me. 10. He has not yet given them to me. 11. We have not yet written to him. 12. They have sent him some. 13. I am not known there. 14. He has not arrived there. 15. They have not asked you for any. 16. We have not sent you any. 17. They have not applied themselves to it. 18. You have not yet complained about it.

The order of the personal pronouns with verbs in the imperative mood is as follows:—*Donnez-le-moi*, Give it me; *Ne me le donnez pas*, Do not give it me; *Donnez-m'en*, Give me some; *Ne m'en donnez pas*, Do not give me any.

Prepositions, adverbs, and conjunctions are uninflected. The first are always, except in the case of *durant*, placed before the words they govern; the second almost invariably after the words they modify; and the third, when copulative, unite words of the same class only.

As a general rule, the nominative case holds the first place in a sentence, the verb follows, and the objective cases, direct and indirect, come after it in order, unless the indirect object is the shorter in expression, in which case it precedes the direct one; as *Le père donna une maison à sa fille*, The father gave a house to his daughter; but *Le père donna à sa fille une maison, un jardin, et plusieurs champs*, The father gave to his daughter a house, a garden, and several fields.

In the grouping of accessary ideas, if they have all the same connection with the verb, no difficulty can arise; but if they have not, one should be placed before the verb and another after it. But this is rather within the province of rhetoric than of grammar.

The analysis of sentences may be either (1) etymological, (2) logical, or (3) grammatical. Etymological analysis engages itself with the formation of the words in a sentence, and traces the derivative words in it back to the primitive ones in which they have their origin; logical analysis shows the relations which ideas (and of course the words by which these ideas are expressed) have one to another, and the part they take in the complete and adequate expression of the ideas brought together in a proposition; grammatical analysis, which is often called parsing, treats of the nature, classification, form, and inflexion of words, and explains the changes which the necessity of consistency of expression has made requisite in a sentence.

A sentence is the expression of an idea in words. It is called a proposition, because by it that which is perceived in the mind as thought is put before (Lat. *propositus*) us in words. A thought fully expressed implies (1) a subject, or matter of thought, and (2) a predicate, or what is said about the subject; sometimes (3) a copula is required to show the relation of union, equivalence, &c., subsisting between the two former terms; as

Subj.	Pred.	Subj.	Copula.	Pred.
Le lion	rugit.	Le lion	est	féroce.
The lion	*roars.*	*The lion*	*is*	*fierce.*

The subject of a proposition may be expressed by a noun, a verb in the infinitive used as a noun, or a phrase, and it may be indicated by a pronoun or an adjective; as *La vertu ennoblit*, Virtue ennobles; *Mentir est un péché*, To lie (lying) is a sin; *Les plus grands orateurs de l'antiquité sont Demosthènes et Cicéron*, The greatest orators of ancient times are Demosthenes and Cicero.

The predicate of a proposition may be expressed by a noun, an adjective (or a participle), a verb, or a phrase; as *Alexandre le Grand était un roi*, Alexander the Great was a king; *Alexandre le Grand était invincible*, Alexander the Great was invincible; *Le cheval galope*, The horse gallops; *La reine Victoria est bien aimée de tous ses sujets*, Queen Victoria is well beloved by all her subjects.

The following sentences are presented to the student (1) as specimens of the manner in which simple statements are made in French; (2) that a comprehensive and varied vocabulary may be readily and interestingly acquired; (3) that, by altering singular nominatives, and where necessary for the sense any other nouns, into plural ones, and the use of *sont* instead of *est*, and *ont* instead of *a*, facility may be acquired, in the only effective way, by practice, in the consistent use of words varying according to variation of signification; (4) that the student may exercise his ingenuity in forming, on the same model, as many new sentences out of the words here given (or any others with which he may be thoroughly acquainted) as he can. The student is recommended not only to study these sentences very carefully, but also to repeat them aloud, so as not only to engage the mind, but to catch the ear and train the tongue.

EXERCISES.

La rose est la reine des jardins,	The rose is the queen of the gardens.
L'amitié est une rose sans épines	Friendship is a rose without thorns.
La neige est un bienfait en hiver,	Snow is an advantage in winter.
Le phoque est un animal amphibie,	The seal is an amphibious animal.
La lune est le flambeau des nuits,	The moon is the torch of night.
La guerre est un grand fléau pour une nation,	War is a great scourge for a nation.
La terre est une petite partie de l'univers,	The earth is a small part of the universe.
La mort d'une mère est une grande affliction,	A mother's death is a great calamity.
Le sage est économe du temps et des paroles,	The wise (man) is sparing of time and words.
L'été est la saison la plus chaude,	Summer is the hottest season.
L'hiver est la saison la plus froide,	Winter is the coldest season.
Le chêne est un grand arbre,	The oak is a large tree.
Le chêne est l'ornement des forêts.	The oak is the ornament of the forests.
La Sibérie est une province de la Russie,	Siberia is a province of Russia.
Le Danube est un grand fleuve,	The Danube is a large river.
Mecca est une ville d'Arabie,	Mecca is a town in Arabia.
Cette orange est mûre et douce,	This orange is ripe and sweet.
La mer est orageuse et profonde,	The sea is stormy and deep.
L'écureuil est vif et agile,	The squirrel is lively and active.
La forêt est humide et froide,	The forest is damp and cold.
L'Afrique a la forme d'un triangle,	Africa has the form of a triangle.
Le cardinal a une robe de pourpre,	The cardinal has a purple robe.
Le lion a une longue crinière,	The lion has a long mane.
Le corbeau a un plumage noir,	The crow has a black plumage.
Chaque pays a ses héros,	Each country has its heroes.
Mon oncle a une étable bien garnie,	My uncle has a well-furnished stable.
Cet ouvrier a la main brulante,	This workman has a burning-hot hand.
Ma tante a une jolie petite colombe,	My aunt has a pretty little pigeon.
Clémentine a un joli bouquet de pensées,	Clementine has a pretty bouquet of pansies.
Le lilas a un delicieux parfum,	The lilac has a delicious scent.
Valentin a un prix donné par son maître,	Valentine has a prize given by his master.
Julien a un maintien pitoyable,	Julian has a wretched deportment.
Ma sœur a un chapeau de paille,	My sister has a straw hat.
Votre maman a un grand bouquet d'œillets,	Your mamma has a large bouquet of pinks.

SECTION III.—CONSTRUCTIVE EXERCISES IN COMPOSITION AND SPEAKING.

1. Taking the word *l'encrier*, the inkstand (derived from *encre*, ink), form sentences (1) with it as subject, and each of the following adjectives (or participles) as an attributive predicate; (2) with these or other suitable adjectives, two and two joined together by *et;* and (3) with several adjectives consistent with each other, connecting the last with the conjunction *et.*

L' encrier est rond, nouveau, vieux, utile, creux, rempli,
The inkstand is round, new, old, useful, hollow, full,
petit, grand, beau, sec, noir, simple, unique, &c.
small, large, beautiful, dry, black, common, single, &c. } as

L'encrier est grand et rond; L'encrier est petit et rempli, &c.

In the same way use as subjects *le livre*, the book; *la plume*, the pen; *le canif*, the penknife; *la dictionnaire*, the dictionary; *la chaise*, the chair; *le crayon*, the pencil.

2. Taking the verbs given in the left-hand column, add to them the accompanying complements one by one in this way—

J'ai vu. Avez-vous vu? J'ai acheté. As-tu acheté? Il a reçu. Elle a reçu. Je cherche. Voulez-vous? Vous aurez. J'ai apporté. Elle apporte. Elle n'a pas.	I have seen. Have you seen? I have bought. Hast thou bought? He has got. She has got. I am looking for. Do you wish? You will have. I have brought. She is bringing. She has not.
Le jasmin; des fleurs fanées; une rose; une tulipe rouge; une violette; ces beaux lis; du lilas blanc; quelques pensées bleues; une marguerite; le chèvrefeuille; du réséda.	The jasmin; some faded flowers; a rose; a red tulip; a violet; these handsome lilies; some white lilac; some blue pansies; a daisy; the honeysuckle; some mignonette.
J'ai vu une rose. Aurez-vous une rose? Je cherche une marguerite. Elle n'a pas les beaux lis.	I have seen a rose. Will you have a rose? I seek a daisy. She has not beautiful lilies.

3. To the following imperatives add the substantive complements individually:—

(1) Fermez, *shut* / Ouvrez, *open* { Ce tiroir, *that drawer;* la porte, *the door;* le livre, *the book;* cette armoire, *this press;* la boite-à-ouvrage, *the work-box;* cette barrière, *this gate;* ces fenêtres, *these windows.*

(2) Donnez-moi, *give me* / Prenez, *take* { Cahier, *exercise-book;* cette feuille de papier, *this sheet of paper;* cette belle esquisse, *this beautiful sketch;* cette grande plume, *this large pen.*

4. To the indicative verbs given add the infinitive verbal complements supplied, making with each two a separate sentence—

Je voudrais. Je demande de. Je désire de. J'espère de. Je préfère à. J'ai resolu de.	I should like. I ask or require to. I wish to. I hope to. I prefer to. I have resolved to.
Etre industrieux [euse]; bien parler français; acheter du fruit; faire une promenade; ne jamais vous déplaire; cueillir des poires; sortir dans le jardin; bien travailler; demeurer dans une belle chaumière; donner cela à ma mère; aller en bateau-à-vapeur; aller en voiture.	Be busy; speak French well; buy some fruit; take a walk; never to displease you; gather some pears; go out into the garden; work well; live in a nice cottage; give this to my mother; go in a steam-boat; go in a carriage.

READING LESSON.

La mécanique est la science du mouvement. Elle nous apprend la nature et les lois du mouvement, l'action et la force des corps moteurs, et la construction et les effets des machines.

Mechanics is the science of movement. It explains to us the nature and the laws of motion, the action and the power of moving bodies, and the construction and results of machinery.

La musique est l'effet harmonieux provenant d'une combinaison de mélodies vocales ou instrumentales.

Music is the harmonious result proceeding from a combination of vocal or instrumental melodies.

La science de l'optique traite de la vision, soit qu'elle s'exerce par les yeux à nu ou qu'elle soit secondée par des instruments particuliers. Elle enseigne la construction et l'usage des téléscopes, microscopes, &c.

The science of optics treats of vision, either when it is exercised by the naked eye or when it is aided by special instruments. It teaches the construction and use of telescopes, microscopes, &c.

La peinture fait partie des beaux-arts; et, par la connaissance des principes du dessin et des effets du coloris, elle nous enseigne à représenter toutes sortes d'objets. On n'est pas bon peintre sans génie original.

Painting constitutes a portion of the fine arts; and, by the knowledge of the principles of drawing and the effects of colour, teaches us how to represent all kinds of objects. No one can be a good painter without original genius.

La philosophie est l'étude de la nature, de l'âme, et de la morale, d'après les principes de la raison.

Philosophy is the study of nature, of the soul, and of morals, according to the principles of reason.

La poésie est la peinture parlante, réprésentant des événements, réels ou de pure fiction, par une succession d'images intellectuelles, exprimées en vers. Elle polit à la fois le cœur et élève l'âme.

Poetry is painting in words, representing events, real or fictitious, by a succession of intellectual images, expressed in verse. It at the same time refines the heart and elevates the soul.

La sculpture est l'art de tailler la pierre ou d'autres substances solides en images.

Sculpture is the art of cutting stone or other solid substances into likenesses (of men or things).

La statistique est une science qui réduit en chiffres toutes les questions de l'organisation sociale, ainsi que toutes les sciences.

Statistics is a science which reduces to figures all questions of social organization, as well as all the sciences.

As a preliminary to further progress in parsing, the student is strongly recommended—having read the definitions of the several parts of speech given in the course of these lessons—to go carefully over several, if not all, of the foregoing reading lessons, and to number them, as shown in the following example, with figures indicative of the nine parts of speech (see p. 111). The parts of speech are each numbered as follows: (1) article, (2) noun, (3) adjective, (4) pronoun, (5) verb, (6) adverb, (7) conjunction, (8) preposition, (9) interjection.

^{1}L'^{2}abeille ^{5}est ^{1}un ^{3}pauvre ^{3}petit ^{2}insecte ^{3}brun; ^{4}c'^{5}est ^{6}cependant ^{1}le ^{3}plus-sage ^{8}de ^{3}tous ^{1}les ^{2}insectes. ^{1}Le ^{2}rossignol, ^{4}ce ^{2}chantre ^{3}harmonieux ^{1}du ^{2}bocage ^{8}pendant ^{1}les ^{3}beaux ^{2}jours ^{1}du ^{2}printemps, ^{5}est ^{1}un ^{3}petit ^{2}oiseau ^{6}également ^{3}brun ^{7}et ^{6}moins ^{3}joli ^{7}que ^{1}le ^{2}moineau. ^{1}L'^{2}abeille ^{5}est ^{1}un ^{2}modèle ^{8}d'^{2}assiduité ^{7}et ^{8}de ^{2}sagesse. ^{3}Heureux ^{1}l'^{2}homme ^{7}et ^{3}heureux ^{1}le ^{2}peuple ^{4}qui ^{5}suit ^{6}sagement ^{4}cet ^{3}excellent ^{2}exemple.

The bee is a poor, little, brown insect; it is, however, the wisest of all insects. The nightingale, that sweet singer of the thickets in the pleasant days of spring-time, is a little bird, brown also, and less beautiful than the sparrow. The bee is a model of industry and wisdom. Happy the man and happy the people who follow wisely this excellent example.

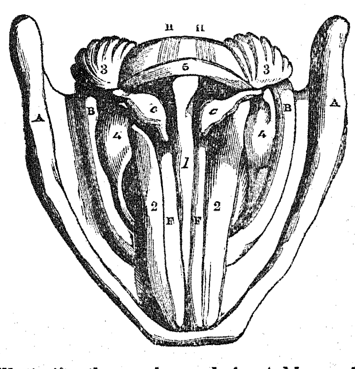
NATURAL PHILOSOPHY.—CHAPTER XVI.

ACOUSTICS—*Continued.*

THE VOCAL ORGAN OF SOUND—VOWEL SOUNDS—THE PHONOGRAPH—OPTICAL VIBRATORY MOTIONS OF SOUND—THE PHONANTOGRAPH—KÖNIG'S MANOMETRIC FLAME—KUNDT'S METHOD OF DETERMINING RATES OF VIBRATION IN SOLIDS—MUSICAL FLOW OF WATER—MUSICAL FLAMES—SINGING NAKED FLAMES—SENSITIVE SMOKE JETS.

THE organ of *voice* is the most perfect reed instrument known. The *trachea* or *windpipe* is a tube which terminates at one end in the lungs, and at the other in the *larynx*, which is the organ of vocal sound. The larynx (fig. 1) consists of a number of cartilaginous structures, connected together by various muscles, by which great variety and control in the motions are attainable. These muscles are connected with, and move two elastic membranes with broad bases attached to the larynx, and furnished with sharp edges, called the *vocal chords*, F F. According to the pressure of the muscles these chords are more or less tightly stretched, and the space between them, the *vocal slit*, becomes narrower or wider. When the air is forced from the lungs through the vocal slit which separates the chords, they are thrown into a state of vibration. The rate of this vibration is varied according to the tension, and the sound is changed in pitch. The sweetness and smoothness of the voice depend on the

Fig. 1.



In above illustration the muscles are designated by numbers, the cartilages by letters. 1. The crico-thyroideus (at the rima of the glottis). 2. The thyro-arytænoideus. 3. The crico-arytænoideus posticus. 4. The crico-arytænoideus lateralis. 5. Half of the arytænoideus transversus and of the obliqui. A. The thyroid cartilage. B. The cricoid. C. The arytænoids. F. The vocal or inferior laryngeal ligaments. H. The ligaments which tie the arytænoids to the cricoid.

The crico-thyroid stretch the vocal ligaments; the thyro-arytænoid relax them; the posterior crico-arytænoid open the glottis; the lateral crico-arytænoid and the posterior arytænoid narrow or close it.

perfect closing of the vocal slit at regular intervals during the vibration. The roughness of the voice in colds is stated by Helmholtz to be due to mucous matter getting into the slit of the glottis. The promptness and accuracy with which the vocal chords change their tension, their form, and the width of the slit between them render the voice the most perfect of musical instruments.

The formation of the vowel sounds for some time excited much attention. Wheatstone was the first to elucidate the true theory. Vowel sounds may be produced in any pitch, and the difference in them arises from the circumstance that to form a given vowel sound one or more characteristic notes, which are always the same, must be added. These change with the syllable pronounced, but depend neither on the pitch of the note nor on the person who emits them. In the organ of voice the *reed* is formed by the vocal chords associated with the resonant cavity of the mouth, which can so alter its shape as to resound at will, either to the fundamental tone of the vocal chords or to any of their overtones. The mouth therefore enables the *mixing together* of the fundamental tone and the overtones of the voice in different proportions. Different vowel sounds are therefore due to different combinations of the two. The form and cavity of the mouth can be greatly modified by the extent to which it is opened, by the position of the tongue and the lips. When the mouth is adjusted so as to produce the broad *a*, as in *father*, it has a kind of funnel shape, with the wide part outwards; for *o*, as in *more*, the effect resembles that of a bottle with a wide neck; and for *u*, as in *poor*, it resembles a bottle with a narrow neck. For the remaining vowels, *a*, *e*, *i*, the effect is as if the bottle were prolonged by a tube, formed by contracting the tongue against the palate. When the mouth is adjusted for the position necessary to utter the vowel *u*, it will be found that only a vibrating tuning-fork, giving the note *f*, will be reinforced by the inclosed column of air vibrating in unison with it. This note is there-

ACOUSTICS ——— PHONOGRAPH.

Elevation.

Fig. 1.

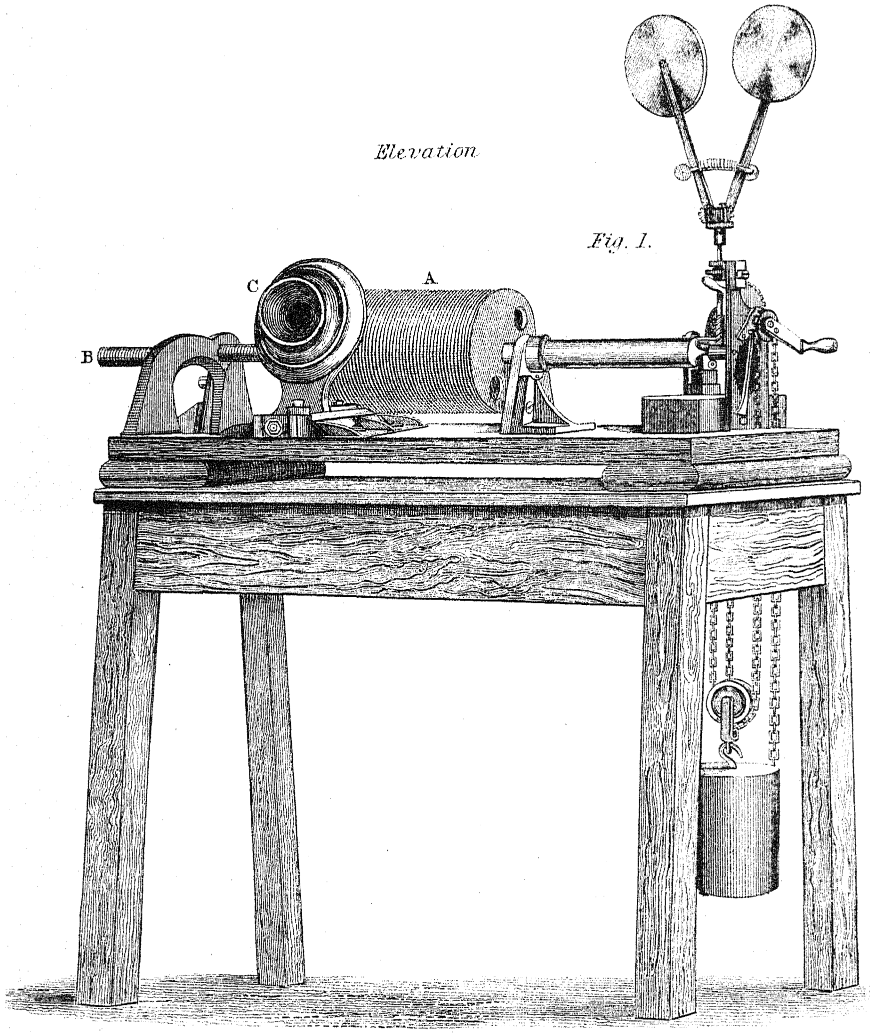
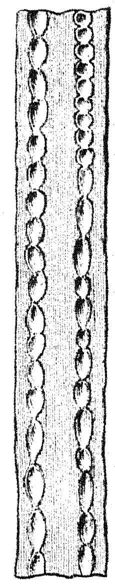


Fig. 2.



Enlargement of indentations on tinfoil.

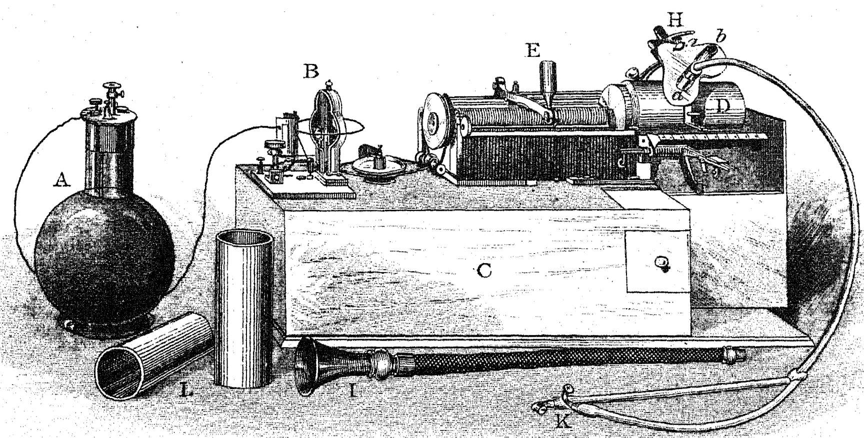


Fig. 3. Edison's Improved Phonograph.

fore the characteristic note of that vowel. In like manner b' is the particular note for *o*, and b'' for that of *a*. The other vowel sounds, such as *i*, have a higher and lower characteristic note, *f* and d^{iv}, and those for *a*, as in *day*, are *d* and a'''. By resolving the human voice into its constituent tones Helmholtz was able to imitate them with tuning-forks, and then, by combining them appropriately together, to produce the vowel sounds. The articulate tones of the human voice are the result of the combinations of the fundamental tone and the harmonics of the column of air set vibrating in the cavity of the mouth by the action of the vocal chords opening and closing the vocal slit.

By very analogous means Edison has devised a most ingenious apparatus for stereotyping the voice-vibrations and reproducing them at will, so as to cause the articulations and tones of the speaker's voice to resound as a retranslation of the original vibrations. The apparatus is alike remarkable for the extreme simplicity of its construction and the marvellous results which it produces. This instrument is termed the *phonograph* or *sound writer*. It consists essentially of a brass cylinder, A, about 10 inches long and 3 inches in diameter (fig. 1, Plate XV.) Upon the surface of this cylinder is a very accurately constructed spiral groove, the threads of which are about one-tenth of an inch apart. The cylinder is mounted on an axis turned into a screw at one end, B, the pitch of which is the same as that of the groove on the cylinder. The axis is either turned by a handle, and the regularity of the motion maintained by a heavy fly-wheel attached to the other end, or it may be actuated by wheelwork and a weight governed by a fly, as shown in our Plate. A sheet of tinfoil is fastened smoothly round the surface of the cylinder, and a mouth-piece, C, is placed opposite, and supported on an arm, which may be moved to and from the surface of the cylinder by a lever attached. At the bottom of the mouth-piece is a thin elastic metal disc about the hundredth of an inch in thickness. At the centre of the back of this plate, by means of a spring lever attached to the arm carrying the disc, a small steel point, rounded at the end, is fixed; by careful adjustment of the disc this point gently presses against the surface of the tinfoil just over the spiral indentations of the groove. Two small pieces of rubber tubing are frequently placed between the surface of the disc and the lever spring carrying the steel point. Any vibrations, therefore, of the elastic metal disc will be transferred to the steel point by the intervention of the elasticity of the piece of rubber tubing between the disc and the point. If the handle be now turned the thread on the axis causes the cylinder to move forward so as to keep the groove always under the point. When the metal diaphragm is at rest and the handle is turned, the point marks a spiral line of uniform depth on the tinfoil. When the disc is made to vibrate by speaking or singing into the mouth-piece C, while at the same time the cylinder A is kept in revolution with a uniform motion, a series of dots or indentations are produced on the tinfoil, the depth of which will exactly represent *the densities of the different portions of the sound-waves intercepted by the disc.* The tinfoil being a non-elastic substance retains them permanently. Although these impressions upon the tinfoil appear to the eye as a successive series of points or dots, yet when examined under the microscope they are seen to have a distinct form of their own, and a longitudinal section presents an outline closely resembling the jagged edge of a König's flame. After talking into the mouth-piece, if the cylinder be set back to its original position, the part the mouth-piece performs will be reversed, for it will vibrate by the point working over the indentations of the tinfoil along the groove, and the vibrations thus set up in the metal diaphragm are communicated to the air by the mouth-piece, and the articulate tones of the voice are reproduced. In this way Edison has reproduced speech, and the quality and tones of the speaker's voice. If the velocity of rotation of the cylinder is increased the pitch of the speech is altered, and if the motion is not uniform, then, when a song is given, the reproduction is incorrect as regards the musical intonation. There is great difference in the distinctness with which some of the consonants and vowels are reproduced; the *s* is very difficult to successfully articulate. When the cylinder of the phonograph is rotated the reverse way the individual letters retain their character, but the sounds of both the words and letters are reproduced in the reverse order. If two or three persons sing the parts of a song at the same time into the mouth-piece, the phonograph picks up the combined vibrations of the disc, with the remarkable result that the song is reproduced by the phonograph as either a duet or trio, as the case may be.

To get rid of an unpleasant metallic sound produced by the instrument above described, Mr. Edison has, in his most recent form of phonograph, substituted a cylinder of wax for the original tinfoil. This is shown in fig. 2 of Plate XV., in which C is a case holding an electro-motor, actuated by the bichromate cell A, which furnishes the power to drive the phonograph cylinder D. The rate is regulated by the governor B. The endwise motion of the wax cylinder is given by the screw E, which forms part of the axis on which it is secured. The frame H extends across the cylinder, and carries the recording mouth-piece *b*, and the repeating mouth-piece *a*, to either of which an india-rubber tube can be attached. That used for speaking into is shown at I, and that for listening to the contents of the *phonogram* at K. The latter has two ear branches.

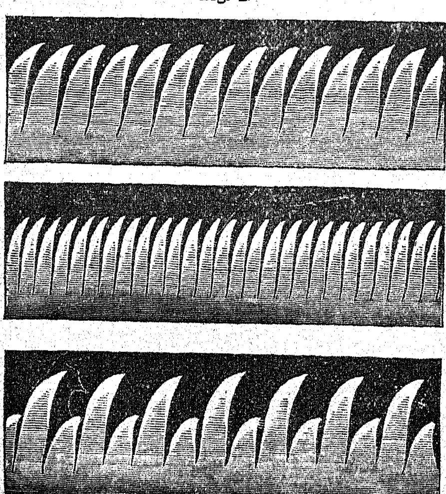
The wax cylinders are removable, and can be forwarded by post to a correspondent, who by fitting them on a similar machine can make them repeat their message at will. It is said that there is no practical limit to the number of repetitions obtainable from one phonogram, but if it is considered desirable to preserve it, it can be copied by electrotyping, and a metal cylinder thus produced, from which any number of wax ones can be moulded. In order to use one of the cylinders over again for a fresh message it is only necessary to adjust a small knife upon the same arm which bears the diaphragm stylus. This cuts off a fine shaving of wax as the cylinder turns, and leaves a fresh surface ready for the action of the point which impresses the message upon it.

The vibratory motion of a solid body has been rendered visible to the eye by an apparatus devised by Lissajou, so that the vibrations of two sounding bodies may be compared, and the exact relation between them determined without reference to the ear. The method depends on the persistence of visual sensations on the retina, which retains an impression for about one-seventh of a second. Lissajou's method consists in fixing to one of the prongs of a tuning-fork a small metallic mirror, the other prong having a counterpoise attached to balance the vibratory motion of the prongs and render it persistent and regular. At a short distance from the mirror is placed a lamp, shaded by a dark chimney, from which, through a small hole, a pencil of light strikes on the mirror as a single luminous point, and is reflected on a screen by a second fixed mirror and achromatic lens placed in position. When the tuning-fork is set vibrating the image on the screen elongates and forms a persistent line, which diminishes in length in proportion as the amplitude of the oscillation decreases. If the mirror is made to rotate during the period of vibration, by turning the tuning-fork on its axis, the straight line on the screen assumes the form of a sinuous line. By employing two tuning-forks Lissajou obtained the optical combination of two vibratory motions, first in the same direction and then at right angles to each other. When the tuning-forks passed their position of equilibrium in the same time, and in the same direction, the image attained its maximum, and the image was at its minimum when they passed at the same time but in opposite directions. Between these two extremes the amplitude of the image varied according to the time which elapsed between the exact instant at which the tuning-forks passed through their position of rest respectively. The ratio of this time to the time of a double vibration is called a *difference of phase* of the vibration. Where the two tuning-forks are in *unison* the luminous image gradually diminishes in length in proportion as the amplitude of the vibrations diminishes; but if the pitch of one is slightly different the magnitude of the image changes periodically with the beats resulting from the unequal vibrations; thus, while the eye observes the pulsations of the image the ear at the same moment detects the imperfect harmony.

When one of the forks is set vibrating horizontally and the other vertically, and their motions projected on a screen by mirrors, on vibrating the horizontal fork a horizontal luminous image is seen, while the vibrations of the other will produce a vertical image. When both forks vibrate simultaneously, the two motions combine and describe a more or less complicated curve, the outline of which is governed by the number of vibrations of the two forks in a given time. By means of this curve the number of the vibrations of any two sounding bodies may be compared. When the two forks vibrate in unison the image is a straight line, which opens out into an ellipse of greater or less minor axis according to the difference of phase of the vibrations. If the two forks are not quite in unison the initial difference of phase is not maintained, and the curve passes through all its variations.

An apparatus for recording mechanically the vibrations produced by solid bodies, wind instruments, and the tones of the voice in speaking and singing, or any sound whatever, has been devised by M. Leon Scott, and termed the *phonantograph*. In some respects it resembles the phonograph. It consists of a large resonant chamber somewhat in the form of a barrel, about 18 inches long, and 12 inches at its greatest diameter, made of plaster of Paris. The head of the barrel is open to receive the sound, but the bottom is closed. Through the centre of the bottom a brass tube of some 2 inches diameter is inserted, and terminated by a ring over which a flexible membrane is stretched, the tension of which is adjusted by means of a second ring. Near the centre of this membrane a hog's bristle, which acts as a style, is fixed by sealing wax, and in order to prevent this attachment taking place at a *node* a movable arm attached to the ring can be made to touch or damp the membrane at any required point, to insure that the style is affixed to a vibrating segment of the membrane, and not on a nodal line. When any sound is produced near the apparatus, the air in the barrel, the membrane, and the style are set vibrating in unison with it, and these vibrations are traced by the style on the surface of a sheet of paper covered with a thin layer of lampblack, wrapped round a cylinder mounted on a screw axis placed in front of the point of the style. When the cylinder is turned and the membrane is at rest, the style traces a helix on the lampblack paper, which becomes straight when the paper is removed; but when any sound sets the membrane vibrating the style traces out an undulating line, each undulation of which corresponds to a double vibration of the style. The figures thus obtained faithfully record the number, amplitude, and isochronisms of the vibrations.

Fig. 2.



König has devised a method of determining the vibrations of a sound-wave by transmitting its motion to gas flames. The apparatus in principle consists of a mouth-piece and tube in connection with a vibrating membrane attached to the gas chamber, from whence the flame issues by a jet. When, by the sound-wave entering the mouth-piece, the membrane is set vibrating, the gas in the chamber is alternately compressed and expanded, and hence are produced alternations in the length of the flame, and these differences of height and contour remain constant for different rates of vibration of the sound-wave. In order to render them distinctly visible the flame is thrown on a screen by means of a revolving mirror. So long as the flame burns steadily only a continuous band of light is observed, but the moment the membrane is set vibrating this band of light is cut up into a series of forks and tongues of flame of various contour and elevations, dependent upon the nature of the vibrations of the sound-wave, as shown in fig. 2.

M. Kundt of Berlin has also devised a mode determining the relative velocities of sound in all solid substances capable of being formed into rods. When a glass tube stopped at one end, or at both ends, is caused to vibrate longitudinally, the column of air within the tube is also thrown into vibration, and by covering the interior surface of the tube with a light powder, the manner in which the aerial column divides itself into nodes may be observed. From the division of the column the velocity of sound in the substance of the tube, as compared with its velocity in air, may be determined. Other gases may be employed instead of air, and the velocity of sound in these gases, as compared with its velocity in the substance of the tube, may likewise be determined. Again, the end of a rod vibrating longitudinally may set in vibration a column of air contained in a glass tube, and the ventral segments being rendered visible by light powders, the velocity of sound in the material of the vibrating rod, compared with its velocity in air, may be ascertained.

Savart's experiments on the flow of liquids through small orifices demonstrated that the friction of the issuing fluid through the hole was rhythmic in its action and able to be converted into a musical sound. Thus, if a tube is filled with water, its end being closed by a metal plate which is pierced by a circular hole of a diameter equal to the thickness of the plate, as the water flows from it and sinks in the tube a musical note issues from the tube. This note is due to the intermittent flow of the liquid through the hole, by which the whole column above it is thrown into vibration. The same intermittent action takes place in the friction of gases. The whistling of the wind through the branches of trees and the rigging of a ship, the singing of the rifle bullet as it cleaves the air, the roaring of a chimney, and the moaning tones of the wind through chinks ar creeks in doors and windows arise from the same cause— intermittent rhythmic actic friction. The friction of th will similarly produce mu tones from gas flames; thus a gas flame is inclosed i open tube (fig. 3), the a passing over the flame is th into rapid vibration, musical so being the result; and allowing the high temperature of the umn of air in connection with flame, the pitch of the note is of an open organ pipe of the sa length as the tube inclosing flame. On examining the fla while the note is sounding, it be found that its vibrations made up of a series of total partial extinctions, between every tially recovers its brightness. Th tone of the tube may also be exci nodal divisions of the column c also those of an open pipe wher

Fig. 3.

y two of which the flame partially e overtones of the fundamental ted by the flame, the successive f air within the tube being its harmonics are sounded.

When a note nearly in unison with the tube containing a silent flame is sounded, the flame immediately responds to the note by jumping; and if the position of the flame in the tube is properly adjusted, the extraneous sound will cause the flame to sing. While the flame continues singing, if a note nearly in unison with it is sounded, beats are produced, and the flame will jump in uniformity of motion with the occurrence of the beats.

The singing noise of a naked flame issuing from a gas burner, when the pressure of the gas is too great, is caused by the state of vibration into which the gas is thrown in the orifice of the burner by the excess of pressure. When the vibrations of the gas in the orifice of the burner are aided by the vibrations in the air caused by any outside sound, the flame will *flare* under a pressure *less* than that which of itself would produce flaring. Gas under an excess of pressure vibrates at a defined rate in passing through the burner, and to produce the maximum effect upon the flame the superposed sound-vibrations should be at the same rate as those of the gas issuing under pressure. When such is the case, and the flame is brought nearly up to the flaring point, it becomes acoustically so extremely sensitive to pulsations, that whistling or clapping the hands at a distance of 30 or 40 yards will throw it into strong agitation. The striking of a bell will cause it to exhibit simultaneous diminution of the light with every recurrent stroke of the hammer. The same effects may be produced with smoke jets, which shrink in proportion to their length to a far greater extent than a flame. Smoke jets are so sensitive that they will respond to the voice, and will perform a series of rapid leaps to the notes of a musical box, some of the tones of which will cause the smoke jet to gather itself up at the top of the jet into a bunch, others will cause the column to contract itself into a *cumulus* not much more than an inch in height from the end of the issuing burner. To produce such effects a perfectly still air is necessary. Smoke jets are more sensitive than the most sensitive flame.

A small jet of water allowed to descend from a circular hole, if it be carefully examined, will be found to be composed of two parts, the one calm and continuous, the other disturbed and formed of a succession of drops. As it descends the continuous portion gradually decreases in diameter, and at the maximum point of contraction the course of the jet downwards is characterized by periodic swellings and contractions composed of small liquid spherules, the apparent continuity being due to the retention of the impressions of the falling drops upon the retina of the eye. These drops as they descend are continually changing their form. At first the drop is a spheroid with its major axis vertical; it then changes into a sphere, and finally assumes the shape of a flattened spheroid. The contractions of the jet will be found at those places in the falling column where the longest axis of the drops are vertical, and the swellings where the longest axis becomes horizontal. Savart found that invariably between every two of the larger drops was a third of much smaller dimensions, and he traced these pulsations to the issuing orifice; they are extremely sensitive to sonorous vibrations, and under moderate pressure, if they succeed each other with sufficient rapidity, produce a feeble musical tone. When a note in unison with that of the tone produced by the jet is sounded near it, the limpid portion of the jet instantly shortens. The continuous portion of the jet may also be caused to enter water silently; but on sounding vigorously a tuning-fork giving a suitable note, the rattle of air-bubbles is instantly heard, the disconnected portion of the jet rising above the surface of the water. When the jet is thrown at various angles to the horizon, in certain cases sonorous vibrations will cause it to divide into two or three branches, and the scattered drops of the descending parabolic jet may be drawn together and closed up, forming an apparently continuous liquid arch. The phenomenon of *beats* upon the jet may be produced either by sounding two slightly dissonant pipes or two tuning-forks. When the forks are set vibrating the beats are heard, which will be responded to by the jet uniting and disconnecting its descending drops in uniformity with the production of the beats

ARITHMETIC.—CHAPTER VIII.

MULTIPLICATION OF FRACTIONAL NUMBERS.

Good clear ideas are indispensable to accurate arithmetical work. Considerable difficulty often arises in the endeavour to solve fractional problems in consequence of the learner comparing the fractions given with each other, instead of comparing them with the unity of which they indicate a part. By thinking of unity as an entire thing, to which a fraction has fixed relation, we get a clear notion of a fraction as (1) a part (or a given number of parts) of a whole number as a unit, and (2) of like parts of that unit. For example, $\frac{3}{7}$ as a fraction indicates that some unity as an integral quantity has been (or is to be thought of as being) divided into *seven* parts, of which three parts exactly alike in value to each other are to be taken; in other words, the unit is divided into seven parts, of which three are denoted by the fraction. The readiness to grasp the idea of the unitary basis of fractional expressions is, accidentally perhaps, weakened practically by the notion too easily adopted from the results of integral arithmetic, that a fraction indicates, as a matter of fact and experience, an unfinished, and, in the circumstances, an impossible division. A fractional quantity is in reality, however, quite free from this impression of impossibility and incompleteness. It implies in its very existence and statement that, for the purpose in hand, the computation is possible, and is really completed and *expressed*, though the meaning of the expression may require to be wrought out into a nearer approach to certainty or accuracy of perception. The fractional form of expression for an unexecuted operation in division *is* the same as that of a fraction, but its meaning is not quite the same. It implies the notion of an unattained (or unattainable) result, but a fraction implies that the result is really attainable and expressed. Let us suppose any ideal unity to be divided into four parts, and that three of these are to be taken, we see at once that whether the unity is that of 100, 1000, 1,000,000, &c., the relation is the same and fixed. The denominator fixes the number of parts into which unity is to be divided, and the numerator tells how many of these parts are to be regarded as involved in the question before us; *e.g.* let either of the foregoing units be divided by 4, and the respective answers will be 25, 250, and 250,000, and three times each of these will be respectively 75, 750, and 750,000, so that three-fourths of each of these numbers will be indicated respectively by $\frac{75}{100}$, $\frac{750}{1000}$, and $\frac{750,000}{1,000,000}$. Practically the same result will be brought about whether we multiply the unit implied in the denominator, of whatever value it may be, by 3, and divide the answer by 4, or divide the denominator as a unit and multiply the result by 3; *e.g.*

$$100 \times 3 = 300 \div 4 = 75, \text{ and } 100 \div 4 = 25 \times 3 = 75.$$

Figurate arithmetic deals with integers involving distinctly perceptible units; *fractional* arithmetic deals with equally distinctly perceptible units, where we take the denominator as the index or interpreter of the unitary basis of calculation, and the numerator as the definite expression of the number of times the denominated quantity is to be taken, used, thought of, &c. Thus, three-fifths indicates some one thing —a unit—as divided into five parts, of which three are to be taken; and hence it involves (1) a distinct apprehension of a unit, and (2) an equally distinct apprehension of this unit divided as denominated—taken a certain number of times. Let us now apply this idea to the multiplication of fractions.

Suppose we require to multiply $\frac{3}{4}$ by 5. This, by the meaning attached to multiplication, in integral arithmetic, is to take $\frac{3}{4}$ as many times as there are units in 5, that is, five times. The process and the result are therefore exhibited thus:—

$$\frac{3}{4}+\frac{3}{4}+\frac{3}{4}+\frac{3}{4}+\frac{3}{4}=\frac{15}{4}=15\div 4=3\frac{3}{4}.$$

But this is exactly the same as if we had multiplied the numerator 3 by 5, and placed the denominator under the product; *e.g.*

$$\frac{3}{4}\times 5 = \frac{3\times 5}{4} = \frac{15}{4} = 15 \div 4 = 3\frac{3}{4}, \text{ as before.}$$

Again, suppose we require to multiply $\frac{3}{20}$ by 5. Proceeding to add these, as multiplication implies, we get

$$\frac{3}{20}+\frac{3}{20}+\frac{3}{20}+\frac{3}{20}+\frac{3}{20}=\frac{15}{20}=\frac{3}{4}.$$

But this last result is just the same as if we had divided the denominator by the multiplier, and placed the numerator over the quotient; *e.g.*

$$\frac{3}{20}\times 5 = \frac{3}{20\div 5} = \frac{3}{4}, \text{ as in the previous instance.}$$

From these two examples we learn that a fraction is multiplied by a whole number either (1) by multiplying its numerator, or (2) dividing its denominator by that number. The former of these methods is, however, the more general, since we can always multiply; the second can only be *conveniently* applied when the denominator of the fraction is exactly divisible by the multiplier given. The following cases may now be verified:—

$$\frac{6}{11}\times 5 = \frac{6\times 5}{11} = 2\frac{8}{11};\ \frac{11}{18}\times 3 = 1\frac{5}{6};\ \frac{8}{19}\times 38 = 16;$$

$$\frac{6}{35}\times 7 = \frac{6}{35\div 7} = 1\frac{1}{5};\ \frac{9}{25}\times 5 = 1\frac{4}{5};\ \frac{5}{63}\times 9 = \frac{5}{7}.$$

The division of a fraction by a whole number is equally simple. Take this question for instance—

What is $\frac{3}{4}$ divided by 6? We require here to perform an operation upon $\frac{3}{4}$ which is exactly the inverse of multiplying it by 6. To find the proper result of the operation $\frac{3}{4}\times 6$ we may write either $\frac{3\times 6}{4}$ or $\frac{3}{4\div 6}$ as we please.

Each form of expression is correct, as we may see by inspection.

$$\frac{3\div 6}{4}\times 6 = \frac{18\div 6}{4} = \frac{3}{4}, \text{ and } \frac{3}{4\times 6}\times 6 = \frac{3\times 6}{4\times 6} = \frac{3}{4}.$$

The proof that a quotient is correct, consists in its reproducing the dividend when it is multiplied by the divisor.

The rule for the division of a fraction by an integer is this: either (1) *multiply the denominator, or* (2) *divide the numerator by the whole number.*

$$\text{Thus } \frac{8}{9}\div 4 = \frac{2}{9};\ \frac{8}{7}\div 7 = \frac{8}{49};\ \frac{55}{71}\div 11 = \frac{5}{71}.$$

The multiplication of a whole number by a fraction is just the converse of the multiplication of a fraction by a whole number. In reality, the two operations coincide. But the principle that A multiplied by B is the same as B multiplied by A, although very clear when A and B are whole numbers, is not so immediately apprehended when applied to fractions. Thus, no one hesitates to admit that $\frac{2}{3}$ multiplied by 6 is $\frac{12}{3}$, or 4; but it requires a little consideration to satisfy the mind before which it has been placed for the first time, that 6 multiplied by $\frac{2}{3}$ is also 4. It requires, in fact, an extension of the meaning which has been attached to the word *multiplication* in integral arithmetic. This is usually defined to be the taking a number (it may be whole or fractional) as often as the number which we call our multiplier contains 1. But all proper fractions are *less* than 1; multiplication therefore by any such fraction appears, by the definition, to be an absurdity. The difficulty, however, lies in the want of comprehensiveness in our mode of expression. Instead of saying—*Take* A (*the multiplicand*) *as often as there are units in* B (*the multiplier*); let us put it as follows:—*Perform the same operation upon* A *that is performed upon* 1 *in order to form* B. This includes all that is meant, and does not restrict us to whole numbers; for B may be a fraction formed by dividing 1 into parts, and taking some of those parts. Let us show how this applies to practical work. We give A and B particular values, as in this question—What is 18 multiplied by $\frac{5}{6}$? The process would take this form:—

Whatever is done with 1 in order to make $\frac{5}{6}$, is to be done with 18; but to make $\frac{5}{6}$ we divide 1 into 6 parts, and take 5 of them; therefore to make $18\times\frac{5}{6}$, we must also divide 18 into 6 parts, and take 5 of them. Now 18 distributed into 6 parts is $3+3+3+3+3+3$, and 5 of these parts make 15. This result is likewise the product of $\frac{5}{6}$ by 18, and hence we conclude that

$$18\times\frac{5}{6} = \frac{5}{6}\times 18 = \frac{18\times 5}{6} = \frac{90}{6} = 15.$$

The new notion to be formed is this:—Any number multiplied by another must give a product bearing the same relation to the number which is to be multiplied that the multiplier bears to 1. The first idea of the meaning of the word *multiplication* is fully included in this enlarged meaning; but this it applies to all cases, whether the multiplier be greater or less than unity. To show its application where the multiplier and multiplicand are both fractions, let us take the question—

What is $\frac{3}{4}$ multiplied by $\frac{5}{7}$? Whatever is done with 1 to make $\frac{5}{7}$ is to be done with $\frac{3}{4}$; we must therefore divide $\frac{3}{4}$ into 7 equal parts, and take 5 of them. Now putting for $\frac{3}{4}$ its equivalent $\frac{3\times 7}{4\times 7}$, that is $\frac{21}{28}$; if $\frac{21}{28}$ be divided into 7 equal parts, each of them is $\frac{3}{28}$, and if 5 of these parts be taken the result is $\frac{3\times 5}{28} = \frac{15}{28}$; therefore $\frac{3}{4}$ multiplied by $\frac{5}{7}$ is $\frac{15}{28}$, and the same reasoning may be applied to any other fractions. We see, then, that as

$$\frac{3}{4}\times\frac{5}{7} = \frac{15}{28}, \text{ which is} = \frac{3\times 5}{4\times 7}, \text{ and yields } \frac{15}{28},$$

the product of two fractions is found by multiplying together the two numerators for the new numerator, and the two denominators for the new denominator. This fact furnishes our rule for the multiplication of fractions. It is, moreover, a *general* rule; for, if this product $\frac{15}{28}$ is to be multiplied by a third fraction, for instance $\frac{3}{8}$, the result will be found by the same kind of reasoning and similar operations to be $\frac{45}{224}$—that is, $\frac{3\times 5\times 3}{4\times 7\times 8}$. And so on of any greater number of fractions. Hence the general rule for multiplying any number of fractions together is:—

Multiply all the numerators together for the numerator of the product, and all the denominators together for its denominator.

$$\text{Examples: } \frac{2}{7}\times\frac{5}{9} = \frac{10}{63};\qquad \frac{5}{3}\times\frac{11}{12} = \frac{55}{36};$$

$$\frac{3}{2}\times\frac{5}{7}\times\frac{3}{11} = \frac{45}{154};\ \frac{3}{16}\times\frac{7}{20}\times\frac{3}{11} = \frac{63}{3520}.$$

In order thoroughly to satisfy himself of the truth of the rule for the multiplication of one fraction by another, there is another mode which the student may practise. It is this:—Supposing we are asked to find $\frac{8}{9} \times \frac{5}{7}$.

$$\text{Then, } \frac{8}{9} \times 5 = \frac{40}{9}\text{; and } \frac{8}{9} \times \frac{5}{7} = \frac{40}{9} \times 7 = \frac{40}{63};$$

or, as is the result by the foregoing rule, $\frac{8}{9} \times \frac{5}{7} = \frac{40}{63}$.

All other cases may be resolved in the same way.

Suppose it is required to multiply together $\frac{10}{21}$ and $\frac{7}{8}$. The product may be written thus:—

$$\frac{10 \times 7}{21 \times 8}\text{, that is } \frac{70}{168}\text{, which being reduced by 14 is } \frac{5}{12}.$$

But this result might have been obtained directly, by observing (1) that 10 and 8 are both measured by 2, and (2) that 7 and 21 are each measured by 7; and that, in fact,

$$\frac{10 \times 7}{21 \times 8} \text{ is equivalent to } \frac{5 \times 2 \times 7}{3 \times 7 \times 2 \times 4},$$

so that dividing both the numerator and denominator by 2×7, this compound expression is reduced to the simpler one $\frac{5}{3 \times 4} = \frac{5}{12}$. We, therefore, conclude that factors which are common to a numerator and denominator may be expunged before multiplication.

$$\text{Thus,}\quad \frac{16}{24} \times \frac{35}{21} = \frac{8' \times 2}{8' \times 3} \times \frac{7' \times 5}{7' \times 3} = \frac{2}{3} \times \frac{5}{3} = \frac{10}{9};$$

$$\frac{2}{3} \times \frac{3}{4} \times \frac{5}{6} \times \frac{4}{5} = \frac{2 \times 3' \times 5' \times 4'}{3' \times 4' \times 6 \times 5'} = \frac{2}{6} = \frac{1}{3}.$$

The *ticked* figures indicate those which are common alike to numerator and denominator, and may therefore be deleted.

The word *of* between two fractions is frequently used instead of the sign of multiplication; this expression is sometimes called a compound fraction. For instance, $\frac{2}{3}$ *of* $\frac{3}{4}$ is called a compound fraction, but $\frac{2}{3} \times \frac{3}{4}$, which means the same thing, is called a product. The arithmetic of the two forms is strictly the same. Our rule for multiplying fractions together applies equally to whole numbers, since any whole number may be expressed as a fraction whose denominator is 1. When the quantities to be multiplied together happen to be made up of integers and fractions, the most convenient mode of proceeding often is, to convert them into improper fractions, and operate upon the results as directed; *e.g.*

$$3\frac{2}{9} \times 7\frac{1}{3} = \frac{29}{9} \times \frac{22}{3} = \frac{638}{27} = 23\frac{17}{27}.$$

$$45\frac{3}{4} \times 17\frac{2}{3} = \frac{183}{4} \times \frac{53}{3} = \frac{9699}{12} = 808\frac{1}{4}.$$

EXERCISES.

$\frac{2}{7}$ of $\frac{4}{9}$.	$\frac{8}{63}$ *Ans.*	$\frac{7}{12}$ of $\frac{11}{16}$.	$\frac{77}{192}$ *Ans.*
$\frac{4}{11}$ " $\frac{2}{3}$.	$\frac{8}{33}$ "	$\frac{8}{11}$ " $\frac{4}{7}$.	$\frac{32}{77}$ "
$\frac{3}{7}$ " $\frac{19}{20}$.	$\frac{57}{140}$ "	$\frac{3}{4}$ " $\frac{15}{16}$.	$\frac{45}{64}$ "
$\frac{4}{5}$ " $\frac{6}{11}$.	$\frac{24}{55}$ "	$\frac{16}{17}$ " $\frac{11}{12}$.	$\frac{44}{51}$ "

Multiply $\frac{8}{9}$ by $71\frac{4}{5}$.	$63\frac{37}{45}$ *Ans.*
" $\frac{3}{4}$ of $9\frac{1}{4}$ by $\frac{2}{3}$ of 17.	$78\frac{5}{8}$ "
" $\frac{9}{10}$ of 7 by $\frac{11}{15}$ of $87\frac{3}{11}$.	$403\frac{1}{5}$ "
" 7 by $3\frac{3}{4}$.	$26\frac{1}{4}$ "
" 8 by $\frac{7}{9}$.	$6\frac{2}{9}$ "
" 12 by $\frac{5}{7}$.	$8\frac{4}{7}$ "
" 15 by $\frac{6}{11}$.	$8\frac{2}{11}$ "

A merchant owns $\frac{7}{8}$ of a ship, he sells $\frac{4}{11}$ of his share to A. What part is that of the whole ship? $\frac{7}{22}$ *Ans.*

In the following examples the operations may be simplified by cancelling before multiplying.

$\frac{14}{17}$ of $\frac{17}{42}$.	$\frac{1}{3}$ *Ans.*	$\frac{3}{19}$ of $\frac{38}{39}$.	$\frac{2}{13}$ *Ans.*
$\frac{9}{11}$ " $\frac{22}{27}$.	$\frac{2}{3}$ "	$\frac{7}{9}$ " $\frac{9}{11}$.	$\frac{7}{11}$ "
$\frac{4}{9}$ " $\frac{18}{19}$.	$\frac{8}{19}$ "	$\frac{1}{99}$ " $\frac{99}{100}$.	$\frac{1}{100}$ "

THE LATIN LANGUAGE.—CHAPTER IX.

THE NATURE AND USES OF PREPOSITIONS: CLASSIFIED LISTS AND THEIR MEANINGS—LESSONS IN READING: TRANSALPINE GAUL IN THE TIME OF JULIUS CÆSAR—EXERCISES.

LINGUISTS who labour to make the Latin language unlearnable, except by the intense efforts of a strong natural memory, or the sedulous application of an artificial system of mnemonics, seldom appeal to the reasoning faculties of their pupils, and seem to be perfectly regardless of the near relationship which the Romans recognized between *ratio*, the faculty of thinking, and *oratio*, the power of speaking. It is true that the actual facts of a language require to be committed to memory in such an order as shall be easily referred to, and that a good many of these—a knowledge of which some individual students will never require—must be set down in grammars, lexicons, &c. It is not necessary, however, that even these should be arranged and given in a dry, lifeless, and unreasoned way, capable of communicating no instruction to the mind, and unsuited to excite any interest in it. In ordinary books of this sort a large space is occupied with the minutiæ of the inflected words of the language, but as a general rule the uninflected ones are very briefly dealt with, being set before the eye in lists as a task to the memory. It is a mistaken course to pursue. Though such words are invariable in their form they are exceedingly variable in their signification; and a considerable amount of the perspicuity and grace of language depend upon the student's knowing those specialities of implication which regulate their use and impart idiomatic accuracy to speech.

Among Latin vocables prepositions are usually allotted scant space. They are very rarely fully explained, and thus the student is frequently distressed at the singularly unsatisfactory nature of his translations wherever they occur with any but their most general application. For two reasons we shall deal differently: (1) because the words are highly important in themselves, and (2) because almost all of them are used in English derivatives from Latin words, and carry with them, in very many cases, the peculiarities of implication which they had among the Romans.

Languages differ very much in their etymological complexity (in the number and regularity of their inflexions, for instance) and in their syntactical mode of interweaving words into the consistency of sentences. In the early languages etymology is a living thing, and words are in a state of growth, both by derivation and by internal change. When, however, words settle into form, and usage and habit govern the activities of speech, inflexions become fixed, and inner development is restrained. Syntax legalizes certain forms, and the widening of the community of interests among men necessitates the securing of distinct accuracy of expression. Authority requires to put its stamp upon phraseology. The "rude forefathers" of antiquity were *super grammaticam* (above grammar). They made the laws of language, and did not require to obey them. Since not only the requirements but the resources of logic have made themselves powerful in the construction of propositions, and ingenious refinements of saying what men had to say were introduced, efforts have been made to collect, classify, arrange, and reduce to definite forms the words which are to be used and the manner in which they are to be used. And so we are brought into the region of declensions and conjugations—paradigms or tabulated plans of the various forms in which speech deals with space and time. The cases of nouns, in their primary aim, were to suggest or indicate the positions of objects in relation one to another, and the tenses of verbs to put before the mind the various relations of the changes which take place through the active properties of things, or the operations of men in regard to beginning, continuance, and end. The more numer-

ous, varied, and definite in their forms the cases of nouns were—*i.e.* the more complete and thoroughgoing the case-system or declensions of a language had been made—the fewer prepositions were required, for these cases really contained in themselves those indications of relation which prepositions are employed to represent. Nouns, in inflected languages, are found to consist of (1) an independent and invariable part, which is most frequently called the *root* or *crude-form*, and (2) of an added part, which, while it varies in each case as a termination, is constant in its suggestion of the changed relation in which the thing indicated by the noun is to be regarded; *e.g. rex* denotes a king as a subject of thought; *regis* no longer denotes that subject, but suggests something separate (at least in thought) from king, as, for instance, proceeding from, belonging to, forming part of him; as *regis filia*, a king's daughter; *regis facta*, the doings of a king; *corona regis*, a king's crown; *potestas regis*, the power of a king, &c. Again, *homo* signifies a man, but *hominem* implies a man acted upon or influenced in some direct manner; as *Spes sola hominem in miseriis consolatur*, Hope alone comforts a man in distressed circumstances. When a noun is used in the dative case it shows that some secondary influence or action has affected it; as *Cæsar servo libertatem dedit*, Cæsar gave freedom to the slave. An ablative case implies a person or thing acting as an agent, an instrument, or the means of accomplishing a purpose; as *Cæsar servo mandata misit*, Cæsar sent (his) orders by a slave; *Sol luce sua omnia collustrat*, The sun brightens up all things by his own light. While, therefore, the nominative simply names or designates, the accusative distinguishes an object as distant and divided from the thinker, the actor, that in which influence or the power of change exists, and as that to which action or influence must be directed. The genitive implies the first and simplest form of separation, removal, and differentiation, while the dative suggests rest, nearness, and receptiveness in the person or thing. The ablative is the sign in a person or object named of instrumentality and of sufficient nearness (really or mediately) to be used. Owing to the coarse obvious practicality of the distinctions of the cases and their failure to indicate the more delicate and subtle relations which ripened and extended experience compels the mind to realize and inclines it to express, the declension-cases were found to be inadequate, and the prepositions came to be used with a more careful regard to nicety of distinction of space, time, cause, localization, and relationship than the cases made provision for. The ablative case sometimes in the singular, and always in the plural, of Latin nouns is undistinguished from the dative by any difference of form, and sometimes indeed coincides in meaning with that case. To lessen the possibilities of mistake arising from these similarities, the ablative was frequently marked off from its double by the use of a preposition, so that the special sense requiring indication might be clearly expressed; as *Adversæ res admonuerunt* [*eos*] *religionum*, Misfortunes reminded them of religion; *Putavi eâ de re te esse admonendum*, I thought that thou wert to be reminded of (made wiser by) this affair. Even the genitive in some cases suggested a meaning nearly similar to that of the ablative; as *Vulnus Ulyssi*, A wound of (from or by) Ulysses; *Pauper aquæ*, Poor of (in or for want of) water. In some instances we find in the classical authors a noun ordinarily taking the dative used, when a sense of limitation is implied, in the ablative; as *Postquam est morte datus Plautus comedia luget*, Comedy grieves, since Plautus has been given to death. These idiomatic usages show that great confusion has arisen in regard to the specific distinctions of cases, and that the refinements of keener thought and a closer attention to logical than to verbal consistency of expression have complicated the original composite etymological development of speech, and so led, in fact, to the introduction of many arbitrary rules for the government of the cases of nouns. These rules are founded partly on custom, partly on practical simplicity in teaching, and partly on philosophical principles, and hence they occasion much perplexity to the learner, especially to such learners as rely entirely upon the syntax of the language as it is set forth in rules to be committed to memory and applied empirically for guidance in translation or composition. These are indeed a real convenience to the student who seeks to know the reasons on which they are founded, and who thinks while he applies. He will understand why in some instances prepositions are required to reinforce and clear up the general indications of relation provided for by declension, and will soon discover the importance of knowing the several specific senses which are implied in the individual prepositions. For it accords with all our experience of the simplifications introduced by system and the endeavour to realize and intensify the relations of life and their expression, that differences come to bulk more largely in the mind than coincidences do. On these accounts, the perception of the fulness of significance which the cases originally suggested becomes dim, and—while intricately declined nouns are received and employed as helpful in, if not essential to, the internal structure and effective interlacement of word with word—we try to get hold of some definite, easily understood mark of meaning; and this, prepositions supply. It turns out, however, ultimately that though prepositions are invariable in form, they are exceedingly variable in implication and signification. The perception of the precise shades of meaning to be attached to such words, and the employment of them idiomatically, occasions great difficulty to the learner who merely accepts "on authority" the usual meaning given in grammars and dictionaries. To those who have the advantage of oral teaching, and the will to profit by the master's explanations of those niceties of art, custom, and mental subtilty, it may be quite enough to have an orderly arranged list of such words, with their commoner meaning and examples of their ordinary use (such as is given below); but to students who have no such adviser, and who require to find in books like the "Home Teacher" their substitute for academic or university training, something quite different is indispensable, and this we propose in the sequel to supply—viz. a clearly arranged, carefully defined, and appropriately illustrated view of the prepositions, tracing from their etymological origin (as far as may be) the various distinct gradations of associated signification they severally assume in different locutions, with examples having classical authority for the meanings assigned to them.

Prepositions are words the primary purpose of which is to indicate the relative positions in place or space of the persons or things denoted by the nouns which they connect; as the bridge *over* the river, the fish *in* the water, the bird *on* the bough; the moor *behind* the farm. They next, by analogy, suggest relations of time, as a sort of inference derived from motion in space, whether it be calculated by the movements of the heavenly bodies, by the hands on the dial of a clock, or otherwise; so that we use such phrases as, I shall come *before* 3 p.m., It might have been *about* 9 p.m., It was *towards* noon, They arrived *after* dark, close *upon* ten, as indications of time.

Other analogies extend the range of usage so as to express cause, purpose, means, instrument, manner, &c.; as He died *by* the axe, *with* calmness, *for* his country.

They are called prepositions, from *præpono, prepositum*, to place before, because they are placed before substantives, which require, for the most part, to follow them in the accusative or ablative case.

This name does not apply to all the functions which the word performs, nor is it quite accurate even in regard to the special point in which the definition is founded, for some of them, though only a few, are placed after the noun which they govern; as *Misenum apud*, Near Misenum (see p. 701).

The following thirty-two prepositions govern the accusative case:—

Prepositions.	Significations.	Examples.
Ad,	*to,*	Eo ad Patrem, *I go to (my) Father.*
Adversum,	*towards,*	Adversum deos, *towards the gods.*
Adversus,	*against,*	Adversus me, *against me.*
Ante,	*before,*	Ante omnia, *before all things.*
Apud,	*at, with, among,*	Apud aliquem, *with anyone.*
Circa,	*about, around,*	Circa pectus, *around (his) breast.*
Circum,	*about,*	Circum mœnia, *round the walls.*
Circiter,	*about, near,*	Hæc loca circiter, *near these places.*
Cis,	*on this side,*	Cis Alpes, *on this side the Alps.*
Citra,	*on this side,*	Citra Rubiconem, *on this side the Rubicon.*
Contra,	*against, opposite,*	Contra Italiam, *opposite Italy.*

Prepositions.	Significations.	Examples.
Erga,	*towards*,	Amor erga regem, *love towards the king.*
Extra,	*without*,	Extra urbem, *outside the city.*
Infra,	*beneath*,	Infra dignitatem, *below (his) dignity.*
Inter,	*between, amongst*,	Inter me et te, *between me and you.*
Intra,	*within*,	Intra mœnia, *within the walls.*
Juxta,	*nigh to*,	Juxta viam, *near the road.*
Ob,	*because of, against, for*,	Ob hanc rem, *because of this thing.*
Penes,	*with, possessed by*,	Est penes te, *it is with thee*, or *in thy power*, or *possession.*
Per,	*by, through*,	Ire per urbem, *to go through the city.*
Pone,	*behind*,	Pone castra, *behind the camp.*
Post,	*after*,	Post tres dies, *after three days.*
Præter,	*besides, except, beyond*,	Præter spem evenit, *beyond hope it happened.*
Prope,	*near, nigh to*,	Prope oppidum, *nigh to the town.*
Propter,	*on account of, near*,	Propter merita, *on account of (his) deserts.*
Secundum,	*according to, along, next*,	Secundum artem, *in accordance with art.*
Secus,	*by, along with*,	Secus fluvium, *by (near to) the river.*
Supra,	*above, beyond*,	Supra modum, *beyond measure.*
Trans,	*on the other side*,	Trans Alpes, *on the other side the Alps.*
Ultra,	*beyond*,	Ultra fines, *beyond the bounds.*
Usque,	*as far as, until*,	Usque necem, *unto death.*
Versus,	*towards*,	Romam versus, *towards Rome.*

The following rhythmical arrangement of these prepositions may be useful in keeping the list fresh in the memory:—

ante, apud, ad, adversus,
circum, circa, citra, cis,
contra, erga, extra, infra,
inter, intra, juxta, ob,
penes, pone, post, *and* præter,
prope, propter, per, secundum,
supra, versus, ultra, trans,
circiter, usque, adversum, secus,
And unto these, if motion *be intended,*
Let in, sub, super, subter *be appended.*

The following ten prepositions govern the ablative case:—

A, ab, *or* abs,	*from, by*,	A tergo, *from behind.*
Absque,	*without*,	Absque argumento, *without argument.*
Coram,	*before, in presence of*,	Coram judice, *before the judge.*
Cum,	*with*,	Pugnare cum hostibus, *to fight with the enemy.*
De,	*of, concerning, from*,	De eâ re, *concerning that thing.*
E, Ex,	*out of, from*,	E conspectu, *out of sight.* Ex tempore, *off-hand.*
Præ,	*for, before, in comparison with*,	Non possum scribere reliqua præ lacrymis, *I cannot write the rest for tears.*
Pro,	*for, according to, before*,	Pro hac vice, *for this turn;* pro castris, *before the camp.*
Sine,	*without*,	Sine dubitatione, *without doubt.*
Tenus,	*up to, as far as*,	Collo tenus, *up to the neck.*

In the following lines the prepositions that govern the ablative are so arranged as to rhyme:—

absque, a, ab, abs, *and* de,
coram, cum, *with* ex *and* e,
tenus, sine, pro, *and* præ.

The following five prepositions govern (1) the accusative when motion to, towards, or throughout is expressed:—

Clam,	*unknown to*,	Clam eos, *unknown to them.*
In,	*into, towards (in what direction)*,	Eo in urbem, *I go to the city [so as to be in it].*
Sub,	*under, near*, *before (time)*,	Sub jugum, *under the yoke.* Sub noctem, *before night.*
Super	*on, upon, in addition to*,	Super lapidem, *on a stone;* fames super morbum, *famine upon*, or *in addition to, disease.*
Subter,	*under*,	Subter terram, *under the earth.*

(2) And the ablative when rest, or position in or at is indicated.

Clam,	*unknown to*,	Clam iis, *unknown to them.*
In,	*in, amongst, on (person or place)*,	Sum in urbe, *I am in the city.*
Sub,	*under, before (person or place)*,	Sub judice, *before the judge;* sub scamno, *under the bench.*
Super,	*on, upon*,	Sidunt super arbore, *they sit upon the tree.*
Subter,	*under*,	Subter aquâ, *under the water.*

That, as has been already stated, many prepositions follow the word which they govern, particularly as regards the relative, may be seen from the examples quoted hereunder—

Hunc adversus Pharnabazus habitus est imperator, Pharnabazus was made commander against him.

Diem certam præstiterunt, quam ante, &c., They appointed a certain day, before which, &c.

Se erga, Towards himself.

Cubiculum Cæsaris juxta, Near the bedchamber of Cæsar.

Quos intra citraque, Within and beyond which.

Quem penes est virtus, In whose power is virtue.

Senatu coram, Before the senate.

Quam super, Above which; *His super*, Concerning these things.

Per is sometimes separated from its case; as *Per ego te deos oro*, I entreat you by the gods.

Prepositions are often placed between the substantive and the adjective; as *Certis de causis*, From certain reasons; *Medios inter hostes*, In the midst of enemies.

Palam, *simul*, and *procul* are used, especially by the poets and the prose writers of the later ages, with an ablative, and so may be regarded as prepositions; as *Palam populo rem creditori solvit*, He paid the debt to the creditor in presence of the people; *Procul urbe*, Far away from the city; *Simul nobis*, Along with us.

LESSONS IN READING.

Section I.—On the Forms of Simple Sentences.

Having explained at considerable length the mechanism of inflexion, we may now try to make some use of our acquisitions. Instead of selecting for this purpose short simple sentences of an unsatisfying nature, we shall endeavour to read a portion of Cæsar's "Gallic War," book i., just as it stands, but in such a way as to employ so much of the preceding grammatical instruction as we can, and to excite the mind to a perception of the principles of construction which underlie and regulate the composition of sentences. The first chapter is given with textual accuracy, with the quantity carefully marked to secure the proper enunciation of each sentence. Each sentence is then taken and analyzed into its simplest elements. These are presented with a literal translation, with all the words requisite for the full grammatical expression of the intended sense supplied, and such additional information given in brackets as seemed necessary to make the entire meaning plain. Each sentence is then exhibited in a gradually increasing development, so that the force and power of each word in its place, as it occurs, is brought distinctly into the view of the mind. When these have been diligently studied, not only will the student have acquired a complete translation of the chapter, but he will have before him a large body of real classically constructed and authoritative exemplary sentences, in which he will be able to trace the relation of words one to another, so that when he comes to study the rules of syntax they shall not be to him mere barren rules, but brief statements of what he has himself been able to observe. The chapter is furnished with a vocabulary containing every word occurring in it.

Before proceeding to read, however, it will be necessary to get some clear idea of simple sentences and their parts, and some general notion of how these are related. The following will perhaps suffice for the present:—

A simple sentence is the expression of a single thought; as *Femina loquitur*, The woman speaks; *Homo non loquitur*, The man does not speak.

That of which something is said is called the subject.

The subject must be (1) a substantive, or (2) a term which can be used instead of a noun, such as an adjective, pronoun, infinitive, or clause.

Any finite verb which declares what is said of the subject, and with it makes complete sense, is called the predicate; as *loquitur*, speaks.

In Latin pronoun-subjects are implied in the terminations of the tenses of verbs, so that a single verb may be a sentence, as in Cæsar's famous saying, *Veni, vidi, vici*, I came, I saw, I conquered.

Any finite part of the verb *sum* (i.e. *esse*, to be) is usually a copula, and the word or words which are linked by it to the subject, and so complete the sense, is called a complement, both together forming the predicate.

	Predicate.	
Subject.	*Copula.*	*Complement.*
Homo	est	mortalis,
Man	*is*	*mortal.*
Homines	sunt	animalia,
Men	*are*	*animals.*

The copula, however, is often omitted; as in the sentence *Rari boni*, Good men (are) few, where *sunt* is implied.

Sum, as the mere logical copula, stands either between the subject and predicate, or after them both; as *Homo est mortalis*, or *Homo mortalis est.*

Sum, when it precedes both subject and predicate, is more than the mere copula, and expresses existence emphatically [=exists, there is]; as *Est homo mortalis*, Man is undoubtedly mortal.

Every sentence in Latin, as in English, must therefore contain (either expressed or understood) a subject and a predicate, and may be analyzed in a form similar in most cases to the following examples:—

I. (1) *Subject.*	(2) *Predicate.*	
Cæsar	vincit.	
Cæsar	*conquers.*	
	(a) Copula.	*(b) Complement.*
Cæsar	erat	fortis.
Cæsar	*was*	*valiant.*

II. With an object—

	(2) *Predicate.*	
(1) *Subject.*	*(a) Verb.*	*(b) Object.*
Cæsar	vincebat	hostes.
Cæsar	*used to overcome*	*(his) enemies.*

III. With expressions (extension of predicate) qualifying either subject or predicate, or both—

	(2) *Predicate.*		
(1) *Subject.*	*(a) Verb.*	*(b) Object.*	*(c) Extension.*
Cæsar	vicit	hostes	Galliæ.
Cæsar	*overcame*	*hosts*	*in Gaul.*
Cæsar, auctor Commentariorum,	dedit	mandata	Labieno.
Cæsar, author of the Commentaries,	*gave*	*commands*	*to Labienus.*

In the usual arrangement of a Latin sentence the subject, as the most important word, stands first; and words which modify the meaning of another precede the word whose meaning they modify.

Hence (1) oblique cases mostly precede the verb (or other word) on which they depend; (2) adjectives and dependent genitives precede the substantives to which they belong; and (3) adverbs precede their verbs or adjectives.

Agreement is found between the verb and its nominative case, between the adjective and its substantive, and between two substantives; this last kind of agreement is generally called apposition.

Government is the connection which exists between substantives, adjectives, verbs, adverbs, prepositions, conjunctions, and interjections, with the words governed by them.

Pronouns are always considered as substantives. Adverbs have often neither agreement nor government, but are used to qualify verbs and adjectives. Conjunctions also are often simple connectives.

It is most important in Latin reading to learn to construe, as the taking of words in their grammatical order, so as to get at the sense of a sentence, is technically called. We can only give four brief directions at present—viz.

1. In each sentence seek out first the nominative case; second, the verb with which it agrees; and third, any case which the verb naturally governs.

2. Take all the words agreeing with the nominative case, and as a general rule translate them together, and next all the words agreeing with the governed case, and translate them together.

3. If a verb in the infinitive occurs, look for the finite verb which governs it.

4. Translate the nouns preceded by prepositions along with them, noting particularly their cases.

Section II.—Transalpine Gaul in the Time of Cæsar (about B.C. 58).

The Divisions and General Description of the Country, in which it is to be noticed that Cæsar naturally looks at Gaul from the standpoint of the Roman province. These Divisions were thus geographically situated:—(1) *Aquitania*, including the country from the Pyrenees to the Garonne. (2) *Gallia Celtica*, the country between the Garonne and the Seine. (3) *Gallia Belgica*, between the Seine and the Rhine. (4) *Provincia Romāna*, extending from Aquitania to Lake Leman and the Alps.

The Parts of Gaul.—Gallĭa est omnis divīsa in partes tres; quarum unam incŏlunt Belgæ, altĕram Aqŭitānī, tertiam, qui ipsōrum linguā Celtæ, nostrā Galli appellantur.

The Differences of their Inhabitants.—Hi omnes linguā, institūtis, lēgĭbus inter se diffĕrunt. Gallos ab Aquĭtānis Gărumna flūmen, a Belgis Matrŏna et Sēquăna divĭdit.

The Belgæ.—Hōrum omnĭum fortissĭmi sunt Belgæ, proptĕrea quòd a cultu atque humanitate Provinciæ longissimè absunt, minĭmèque ad eos mercatōres sæpe commeant, atque ea, quæ ad effemĭnandos anĭmos pertĭnent, important; proxĭmīque sunt Germānis, qui trans Rhēnum incolunt, quĭbuscum continenter bellum gĕrunt.

The Helvetians.—Quā de causā Helvetii quŏque relĭquos Gallos virtūte præcēdunt, quòd fĕre quŏtĭdiānis prœliis cum Germānis contendunt, quum aut suis finĭbus eos prohĭbent, aut ipsi in eōrum finĭbus bellum gĕrunt.

Celtic Gaul.—Eōrum una pars, quam Gallos obtĭnēre dictum est, inĭtium căpit a flumĭne Rhŏdăno; contĭnētur Gărumna flumĭne, Oceăno, finĭbus Belgārum; attingit etiam ab Sēquănis et Helvetiis flumen Rhēnum; vergit ad septentriōnes.

Belgic Gaul.—Belgæ ab extrēmis Galliæ finĭbus oriuntur; pertĭnent ad infĕriōrem partem fluminis Rheni; spectant in septentriōnes et ŏrientem sōlem.

Aquitania.—Aquĭtānia a Gărumna flumĭne ad Pyrēnæos montes et eam partem Oceăni, quæ est ad Hispāniam pertĭnet; spectat inter occāsum solis et septentriones.

Section III.—Vocabulary.

A, ăb, abs, prep. (*a* before a consonant, *ab* before a vowel or consonant, and *abs* chiefly before *c*, *t*, or *q*), *from* (as a cause, *i.e. by*).

Absum, fui, esse (ab and esse), *to be away*, *absent*, *distant.* Absunt, 3rd plur., pres. ind.

Ad, prep. *to*, *toward*, *near*—in the direction of.

Alius, a, ŭd, adj. *another; one*, *of more than two.* Gen. alīus, for aliius, dat. alii. Alius . . . alius, *one . . . another.*

Alter, ĕra, ĕrum, adj. *the other*, *one of two*, *the second.*

Animus, i, mas. (the intellectual principle in man), *mind*, *courage.* This is to be distinguished from anima, æ (the living principle in man), *breath*, *air*, *life*, *soul.*

Appello, āvi, ātum, āre (ad, pello), *to speak to*, *to appeal to*, *to name* or *call.* Other compounds of pello are compello, āvi, ātum, āre, *to speak together*, *to address*, *to accuse.* Interpello, &c., *to speak between*, *to interrupt.* This is to be distinguished from pello, pĕpŭli, pulsum, pellĕre, *to drive*, *to beat;* and its compounds, as, appello, pŭli, pulsum, ĕre, *to drive*, *bring*, or *turn to;* compello, pŭli, pulsum, ĕre, *to drive together*, *to force.* Appellantur, 3rd pl., pres. ind., pass.

Aquĭtānia, æ, *Aquitania.*

Aquĭtāni, ōrum, *the Aquitani* or *Aquitanians.*

Attingo, tĭgi, tactum, ĕre (ad, tango), *to touch at* or *upon*, *to reach* or *extend to.* Attingit, 3rd sing., pres. ind.

Belgæ, ārum, *the Belgæ* or *Belgians.*
Belgĭcus, a, um (Belgæ), adj. *of* or *belonging to the Belgæ.*
Bellum, i, neut. *a contest between two, war.*
Căpio, cēpi, captum, ĕre (cĭpio, in composition), *to take.* Capit, 3rd sing., pres. ind.
Causa, æ, fem. *cause, reason, occasion, business, lawsuit.* In abl., with pronoun, *on account of, for the sake of, for which reason.*
Celtæ, ārum, *the Celtæ* or *Celts.*
Celtĭcus, a, um (Celtæ), adj. *of* or *belonging to the Celtæ.*
Cŏlo, cŏlui, cultum, ĕre (*to bestow pains or labour upon*), *to cultivate; to regard, to worship.* From this verb we receive *cultus, cultura,* &c.
Commeo, āvi, ātum, āre, neut. *to go and come, resort, frequent;* from cum (co, col, com, con in composition), prep. *with, along with,* and eo, īvi, ĭtum, īre, irreg. intrans. *to go.*
Contendo, ndi, nsum *or* ntum, ĕre (con, tendo, *to strive* or *struggle with*), trans. *to strain, to exert;* intrans. *to make an effort, to endeavour; to hasten.* Contendunt, 3rd pl., pres. ind.
Contĭnenter (contineo, *to hold together*), adv. *without break* or *stop, continuously, continually.*
Contĭneo, tĭnui, tentum, ēre (con, teneo), *to hold together, to bound, to confine* or *restrain.* Continetur, 3rd sing., pres. ind., pass.
Cultus, ûs, mas. *care, culture, refinement; worship.* Cultura, æ, *tillage.* Compounded with ager, agri, *a field,* agrĭcultura, æ, *husbandry;* agrĭcŏla, æ, *a husbandman.*
Dico, dixi, dictum, ĕre, trans. *to say, tell, mention, relate, assert.* Dicor, dictus, dici, pass. *I am said, reported.* Dicitur, dicebatur, dictum est, impers. *It is said, told, stated, maintained.* Dictum est, 3rd sing., perf. ind., impers.
Dies, iēi, mas. *or* fem. in the sing.; mas. in the plur. *a day.*
Diffĕro, distŭli, dīlātum differre, trans. *to carry* or *put apart,* or *asunder;* intrans. *to differ,* from dī *or* dis (Gr. dia, *through, division, separation*), insep. prep. *asunder,* and fĕro, tŭli, lātum, ferre, irreg. *to bear* or *carry, to bring.* Differunt, 3rd pl., pres. ind.
Dīvĭdo, īsi, īsum, ĕre, *to divide.* Dividit, 3rd sing., pres. ind.
Effemino, āvi, ātum, āre, trans. (from ex, *out of,* and femina, *a woman*), *to make a woman of, to weaken, to effeminate, to enervate.* Effeminandos, acc. pl., fut. part. pass.
Et, conj. *and, also;* et . . . et, *both . . . and.*
Etiam (et, jam, *and, now*), conj. adv. *also, likewise.*
E, ex, prep. *out, out of.*
Exter *or* extĕrus, a, um (ex), *outward.* Superl. extrēmus *or* extĭmus, *utmost, extreme,* from *extra,* prep. *without.*
Fĕrē *or* fermē, adv. *almost.*
Fīnis, is, mas. *or* fem. *end, conclusion.* Fines, plur. *the limits, borders,* or *frontiers of a country; the country itself* (*which these limits include*), and in these senses it is masculine.
Flūmen, mĭnis (from fluo, *a flowing*), *a river, a stream.* See also flūvius, ii, *a river.*
Fluo, fluxi, fluxum, ĕre, intrans. *to flow,* as a liquid. Fluctus, ûs, *a wave* (from the old supine *fluctum*).
Fortis, is, e (fero), adj. *able to bear, strong, brave.* Fortĭtūdo, dĭnis, *ability to bear, intrepidity.* Adv. fortĭter, *bravely.*
Galli, ōrum, *the Gauls, the inhabitants of Gaul* (either in its wider or more limited area, as the sense of the passage requires).
Gallia, æ, *Gaul.*
Gărumna, æ, mas. *or* fem. *the Garumna* or *Garonne.*
Germāni, orum, *Germans,* a name given by the Romans to those living beyond the Rhine, but confined to the inhabitants of the country called Germania, *Germany.*
Gĕro, essi, estum, ĕre, *to bear* or *carry, to carry on.* Gerunt, 3rd pl., pres. ind.
Helvĕtii, ōrum, *the Helvetii* or *Helvetians.* Helvetius, a, um, adj. *Helvetian.*
Hic, hæc, hoc, dem. pron. *this.*
Hispānia, æ, *Spain.*
Humanitas, itatis, fem. (from humanus, a, um, adj. *kind, refined,* homo, inis, mas. *a man*), *refinement, courtesy, polish, good manners.*
Importo, āvi, ātum, āre, trans. (from in, *in,* and porto, *to carry*), *to bring in* (from abroad), *to import, introduce.*
In, prep. *in, into, against.*
Incŏlo, cŏlui, cultum, ĕre (in, prep. and cŏlo, *to cultivate,* or *worship in a place*), trans. *to inhabit;* intrans. *to dwell.* Incultus, a, um (in, neg. for ne, *not*), adj. *uncultivated, rude.* Incolunt, 3rd pl., pres. ind.
Ineo, ivi *or* ii, ĭtum, īre (in, eo), irreg. *to go into, to enter upon, to begin.*
Infĕrus, a, um, adj. *low;* superl. infĭmus *or* īmus.
Inĭtium, ii (ineo, as above), *a beginning, an entrance.*
Instĭtuo, ui, ūtum, ĕre (in, prep. and statuo, *to set* or *place into* or *upon*), *to institute, appoint,* or *establish,* from sto, stĕti (stātum, found only in compounds), āre, intrans. *to stand;* whence also sisto, stĭti, stătum, ĕre, trans. *to make to stand, to set;* intrans. *to stand still, to halt;* and stătuo, ui, ūtum, ĕre, *to set up.*
Instĭtūtum, i (institutus, part. *a thing established*), *a custom* or *fashion, a rule.*
Inter, prep. *between, among, in the midst of; during.*
Ipse, a um, adj. pron. *self, himself,* pl. *themselves;* the very person (or thing) referred to (from is, ea, id, and the intensive suffix pse).
Is, eă, ĭd, adj. pron. *this* or *that; he, she,* or *it.* It refers to an object, without regard (like hic and ille) to order or comparative distance. With the suffix pse it forms a distinguishing pronoun.
Lēgo, āvi, ātum, āre, *to make lawful, to ordain, to send with authority, to send as ambassador, to appoint as lieutenant; to leave as a legacy;* lēgātus, i, *one sent with authority, as ambassador* or *lieutenant;* lēgātum, i, *a legacy.*
Lĕgo, lēgi, lectum, ĕre, *to choose; to gather; to read.*
Lex, ēgis (lĕgo, *a thing to be read*), *a written law, common* or *civil law; a statute.* This is to be distinguished from jus, jūris, *right.*
Lingua, æ, *tongue, speech, language.*
Longissimé, adv. *very much, by far, most distant, furthest off,* from longus, a, um, *long, tall, remote.*
Matrŏna, æ, *the Matrona* or *Marne.*
Mercator, oris, mas. *trader, dealer, wholesale merchant.* Caupo, onis, is *a retail dealer.*
Minime, adv. *the very least.* Parvus, adj. *little;* minor, *less;* minimus, *least.*
Mons, ntis, mas. *a mountain.*
Noster, tra, trum, poss. adj. (nostri, *of* or *belonging to us*), *our, ours.*
Obtineo, ui, tentum, ēre, trans. (from *ob,* for oneself and against others, and teneo, which see below), *to hold by, to possess, to have and to hold, to gain, to acquire;* when neuter, *to hold one's own.*
Occĭdo, cĭdi, cāsum, ĕre (ob, cădo, *to fall against* or *before one*), intrans. *to fall, to go down, to die* or *perish.* This verb is to be distinguished from occīdo, cīdi, cīsum, ĕre (ob, cædo), *to beat* or *cut down, to kill.*
Occāsus, ûs (occĭdo), *a fall, downfall,* or *ruin; the going down of the sun, the west.*
Oceănus, i, *the main sea, the ocean.*
Omnis, is, e, adj. *all, everyone, the whole of.*
Orior, ortus, ŏrīri (of the third conjugation, except the infinitive, and orirer formed from it; as orĕris, orĭtur, &c., but rarely orĕrer. Fut. part. orĭturus); intrans. *to arise* or *spring up.* Oriens (sol), *the rising sun, the east.* Orientem, acc. sing., mas., pres. part. Oriuntur, 3rd pl., pres. ind., deponent.
Pars, rtis, *a part.* Pro mea parte, *to the best of my ability.*
Pĕr, prep. *through, by means of; along.* In composition *through.*
Pertĭneo, tĭnui, —, ēre (per, teneo), intrans. *to hold through; to extend; to belong.* Pertinent, 3rd pl., pres. ind.
Pyrēnæus, a, um, adj. *Pyrenean.*
Præ, prep. *before*—in position, whether in motion or in rest; *before,* in comparison.
Præcĕdo, essi, essum, ĕre (præ, cedo), *to go before, to excel* or *surpass.* Præcedunt, 3rd pl., pres. ind.
Prœlium, ii, *a battle, a general engagement.*
Prohibeo, ui, itum, ēre, trans. (from pro, *for, far off, in defence of,* and habeo, *to have*), *to keep at a distance, to ward off, to hinder, to forbid.* Prohibent, 3rd pl., pres. ind.
Prŏpis, is, e, old adj. *near;* whence the adverb prope, *near;* comp. propius, superl. (propissime, propsime), proxime. Hence also prŏpior, comp. *nearer,* proximus, superl. *nearest, next.*
Proptĕrea (propter ea, *on account of these things*), adv. *for this reason, therefore.*
Quĕ, conj. *and.* Always joined to another word.
Qui, quæ, quod, rel. pron. (of any person), *who, which, that.* This is to be distinguished from quis, quæ, quod *or* quid, interog. pron. (of the third person), *who? which? what?*
Quod (neut. of qui), conj. *that, because.* Propterea quod, *for this reason, that,* or *because.*
Quoque, adv. *also, likewise, too.*
Quŏt, num. adj. indecl. *how many.*
Quŏtīdie (quotus, dies), adv. *as often as the day, daily.* Quŏtīdiānus, a, um (quotidie), adj. *daily.*
Quŏtus, a, um, adj. *what* (*one*), in numerical order.
Quum, conj. *seeing that, since, because.*
Rĕlinquo, īqui, ictum, ĕre (re, insep. part. used only in composition, linquo, īqui, ĕre, *to leave*), *to leave behind, to leave.*
Rĕlĭquus, a, um (relinquo), adj. *left behind, the rest of.*
Rhēnus, i, *the Rhine.*
Rhŏdănus, i, *the Rhone.*
Septentriōnes, um, mas. *seven plough-oxen, the seven stars, the bear; the north.* Septem, num. adj. indecl. *seven.*
Sēquana *or* Sĕquăna, æ, *the Sequana* or *Seine.*
Sōl, ōlis, mas. *the sun.*
Specto, āvi, ātum, āre (frequentative of spĕcio, spexi, spectum, ĕre, *to see, to look at with attention*), *to look upon, behold,* or *examine; to look towards* (with *ad*). Spectat, 3rd sing.; spectant, 3rd pl., pres. ind.

Sui, reflex. pron. It represents the actor or subject as the object of his own act, or as affected by it; hence it has no nominative. Gen. *of himself*, *herself*, *itself*; pl. *of themselves*. Dat. *to* or *for himself*, &c.

Sum, fui, esse, intrans. irreg. *to be*. Est, 3rd sing.; sunt, 3rd pl., pres. ind.

Tendo, tĕtendi, tensum *or* tentum, tendĕre, *to stretch, to strain.*

Tertius, a, um, ord. num. adj. (trēs), *third.*

Trans, prep. *across*, *on the other side of.*

Trēs, trēs, tria, num. adj. *three.*

Trio, ōnis (tero?) mas. *an ox used in ploughing*, &c.

Unus, a, um, num. adj. *one*. Gen. ius, dat. i.

Vergo (versi), —, ĕre, trans. *to bend towards;* intrans. *to lie, incline*, or *look towards*, with *ad* or *in*.

Vĭr, viri, *a man*, *i.e.* in the strictest sense, *not a woman* or *a boy*.

Virtūs, ūtis (vir), *manliness; anything becoming a man; any good property; courage; virtue.*

Section IV.—Analytical Translation, and Lessons in Sentence-building.

1. Gallia est divisa—Gaul is divided. Gallia est divisa in partes tres—Gaul is divided into three parts (*i.e.* portions, provinces). Gallia est omnis divisa in partes tres—All Gaul (*i.e.* Gaul as a whole) is divided into three parts. In contrast with this emphatic position of *omnis*, giving it the meaning "taken as a whole," we may note here its unemphatic use in De B. G., xii. 4, Omnis civitas Helvetia divisa est in quatuor pagos—Each Helvetian (*i.e.* Swiss) state is divided into four districts (cantons). 2. Unam [partem] incolunt Belgæ—The Belgæ inhabit (occupy) one portion. Alteram [partem] incolunt Aquitani—The Aquitani occupy another (*i.e.* the second) portion. Tertiam [partem] incolunt Celtæ—The Celts dwell in the third portion. Ipsorum linguâ Celtæ appellantur—In their own language they are called Celts. Nostrâ linguâ Galli appellantur—In our language they are called Gauls. 3. Hi [populi] differunt—These people (*i.e.* the Celts) differ. Hi omnes differunt—These reckoned as a whole [*i.e.* all these] differ. Hi omnes inter se differunt—All these people differ among themselves. [Illi] lingua differunt—They differ in language. Institutis differunt—They differ in customs. Legibus differunt—They differ in laws. Hi omnes [Celtæ] lingua, institutis, legibus inter se differunt—All these Celtic tribes differ among themselves as regards speech, modes of life, and laws. 4. Gallos ab Aquitanis Garumna dividit—The Garumna [*i.e.* the Garonne] divides the Gauls from the Aquitanians. Gallos ab Aquitanis Garumna flumen dividit—The river Garonne separates the Gauls from the Aquitanians. Gallos a Belgis Matrona flumen dividit—The river Marne divides the Gauls from the Belgæ. Gallos a Belgis Sequana flumen dividit—The river Sequana [Seine] separates the Gauls from the Belgæ. Gallos a Belgis Matrona et Sequana dividunt—The Marne and Seine [forming one common boundary] conjointly divide the Gauls from the Belgæ. 5. Fortissimi sunt Belgæ—The Belgæ are the bravest. Horum [populorum] fortissimi sunt Belgæ—Of these [people] the Belgæ are the bravest. Horum omnium [populorum] fortissimi sunt Belgæ—Of all these [people] the Belgæ are the bravest. Absunt—They are distant. Longè absunt—They are far distant. A cultu longè absunt—They are far away from culture. A cultu longissimè absunt—They are very far away from culture. Ab humanitate absunt—They are far from refinement. Ab humanitate longè absunt—They are far distant from refinement. A cultu atque humanitate longissimè absunt—From [intellectual] culture and refinement [of manners] they are very far distant. A cultu atque humanitate Provinciæ longissimè absunt—They are at the greatest distance from the civilization and urbanity of the Province (*i.e.* of the south-east part of modern France, which about B.C. 120 had been made a Roman province, as territory out of Italy brought under the administrative sway of the empire was called. On this account this maritime district bears the name of Provence, which some derive from *proventus*, an increase, as an extension or outgrowth of the Roman power, and others from *providentia*, forethought, as being brought under imperial administration). 6. Mercatores commeant—Merchants come and go. Mercatores sæpe commeant—Merchants frequently pass to and fro. Ad Belgas mercatores sæpe commeant—Merchants frequently visit the Belgæ. Minimè ad Belgas mercatores sæpe commeant—Very little do the merchants habitually resort to the Belgæ. Mercatores important—Merchants [*i.e.* traders who carry on a wholesale business and travel with their merchandise, as distinguished from *caupones*, retail dealers (chapmen), and from *negotiantes*, capitalists and factors, brokers, who had stated places of business] import (*i.e.* introduce and bring within reach of customers the goods in which they deal). Ad Belgas mercatores important—The merchants import to the Belgæ. Minimè ad Belgas mercatores sæpe important—Very unfrequently do merchants import to the Belgæ. Minimè ad Belgas mercatores sæpe [mercimonia] important—Exceedingly rarely do the merchants [from the commercial centre of Massilia, Marseilles] introduce [goods] to the Belgæ. [Mercimonia] effeminant animos—Merchants' wares weaken [men's] minds. Ea mercimonia ad effeminandos animos pertinent—These (*or* such) commodities tend to the weakening of minds. Ea mercimonia mercatores important—Merchants import such wares. Ad Belgas ea mercimonia mercatores important—Merchants introduce those wares to the Belgæ. Ea [mercimonia] quæ ad effeminandos animos pertinent mercatores important—Merchants import those wares which tend to the weakening of minds (in regard to manliness). Minimè ad Belgas mercatores ea quæ ad effeminandos animos pertinent important—Very rarely do merchants import to the Belgæ those [things] which lead to the weakening of courage (hardihood). Minimè ad Belgas mercatores sæpe commeant atque ea quæ ad effeminandos animos pertinent important—Least of all do the merchants make visits to the Belgæ and introduce those things which tend to the weakening of their courage. 7. Belgæ prope sunt—The Belgæ are near. Belgæ proximi sunt—The Belgæ are nearest. Belgæ proximi sunt Germanis—The Belgæ are nearest to the Germans. Germani trans Rhenum incolunt—The Germans dwell on the other side of the Rhine. Germani sunt populi qui trans Rhenum incolunt—The Germans are the people who dwell on the further side of the Rhine. Belgæ bellum gerunt—The Belgæ carry on war. Belgæ cum Germanis bellum gerunt—The Belgæ carry on war with the Germans. Belgæ cum Germanis continenter bellum gerunt—The Belgæ wage war on the Germans incessantly. Germani sunt populi quibuscum Belgæ continenter bellum gerunt—The Germans are the people with whom the Belgæ incessantly carry on war. Germani sunt populi qui trans Rhenum incolunt, quibuscum Belgæ continenter bellum gerunt—The Germans are the people who dwell beyond the Rhine, with whom the Belgæ continually carry on war. Belgæ proximi sunt Germanis, quibuscum continenter bellum gerunt—The Belgæ are nearest [in territory] to the Germans, with whom they continually wage war. 8. Horum omnium fortissimi sunt Belgæ, propterea quod a cultu Provinciæ absunt—Of all these the bravest are the Belgæ, because that they are at a distance from the [enervating] civilization of the Province. Horum omnium fortissimi sunt Belgæ, propterea quod minimè ad eos mercatores sæpe commeant—The Belgæ are the hardiest of all these [people], because that merchants least frequently resort to them. Horum omnium fortissimi sunt Belgæ propterea quod proximi sunt Germanis—Of all these the Belgæ are the bravest, because they are nearest to the Germans. Horum omnium fortissimi sunt Belgæ, propterea quod cum Germanis continenter bellum gerunt—Of all these the Belgæ are the bravest, because that they carry on war continually with the Germans. 9. Helvetii reliquos Gallos præcedunt—The Helvetians surpass the other Gauls. Helvetii reliquos Gallos virtute præcedunt—The Helvetians excel the other Gauls in valour. Helvetii quoque reliquos Gallos virtute præcedunt—The Helvetians likewise surpass the remaining Gauls in valour. Helvetii prœliis cum Germanis contendunt—The Helvetians contend in battles with the Germans. Helvetii quotidianis prœliis cum Germanis contendunt—The Helvetians contend in daily battles with the Germans. Helvetii fere quotidianis prœliis cum Germanis contendunt—The Helvetians in almost daily battles fight with the Germans. Helvetii Germanos prohibent—The Helvetians keep off the Germans. Helvetii finibus suis Germanos prohibent—The Helvetians keep the Germans off the territories belonging to them (*i.e.* to the Helvetians). Helvetii bellum gerunt—The Helvetians carry on war. Helvetii in finibus Germanorum bellum gerunt—The

Helvetians wage war within the territories of the Germans. Helvetii aut suis finibus Germanos prohibent, aut Germanorum finibus bellum gerunt—The Helvetians either keep the Germans off (*i.e.* from invading) their territories, or wage war on (*i.e.* in *or* within) the territories of the Germans. Helvetii aut suis finibus Germanos prohibent, aut ipsi in eorum [populorum] finibus bellum gerunt—The Helvetians either hinder the Germans from invading their territories, or they themselves carry hostilities [into *or* within] the territories of those [people]. Qua de causa Helvetii reliquos Gallos præcedunt—On which account (*i.e.* for which reason) the Helvetians excel the other Gauls. Helvetii reliquos Gallos præcedunt quod ipsi in Germanorum finibus bellum gerunt—The Helvetians surpass the other Gauls because they themselves carry on war within the territories of the Germans. 10. Galli unam partem Galliæ obtinent—The Gauls dwell in one part (district) of Gaul. Unam partem Gallos obtinere dictum est —It was said that the Gauls possessed one part of Gaul. Una pars initium capit a flumine Rhodano—One part takes its commencement from the river Rhone. Ea pars quam [partem] Gallos obtinere dictum est initium capit a flumine Rhodano —That part which it was said the Gauls occupied takes its commencement from the river Rhone. Ea pars continetur Garumna flumine, oceano, finibus Belgarum—That part is bounded by the river Garonne, the sea, and the territories of the Belgæ. Ea pars attingit flumen Rhenum—That part touches the river Rhine. Ea pars attingit ab Sequanis flumen Rhenum—That part touches the river Rhine on the side of the Seine. Ea pars attingit ab Helvetiis [finibus] flumen Rhenum—That part touches the river Rhine on the side of the Helvetian territories. Ea pars attingit ab Sequanis et Helvetiis flumen Rhenum—That part touches the river Rhine on the side of the Seine and the Helvetian territories. Ea pars vergit ad septentriones—That part inclines towards the seven stars [near the north pole, constituting Charles' Wain, a part of the constellation of the Great Bear, and therefore to "the north"]. Belgæ ab extremis Galliæ finibus oriuntur—The Belgæ take their beginning from the outermost territories of Gaul. Belgæ pertinent ad inferiorem partem fluminis Rheni—The Belgæ extend to the lower part of the river Rhine. Belgæ spectant septentriones—The Belgæ look out into the north. Belgæ spectant in orientem solem—The Belgæ look towards the rising sun. Belgæ spectant in septentriones et orientem solem—The Belgæ look towards [and therefore face] the north-east. Aquitania a Garumna flumine ad Pyrenæos montes pertinet—Aquitania extends from the river Garonne to the Pyrenæan mountains. Una pars oceani est ad Hispaniam—One portion of the sea is on the coast of Spain. Aquitania ad eam partem oceani pertinet—Aquitania extends to that part of the ocean. Aquitania ad eam partem oceani quæ (pars) est ad Hispaniam pertinet—Aquitania stretches to that part of the ocean which is near Spain. Aquitania spectat inter occasum solis et septentriones—Aquitania looks between the setting of the sun and the seven stars [*i.e.* has a north-western aspect].

Section V.—Complete Version of the Foregoing Latin Text.

Considered as a whole Gaul is divided into three portions, of which the Belgæ inhabit one, the Aquitanians another, [and] those who in their own speech are called Celts, in ours Gauls, the third. These all differ one from the other (1) in language, (2) in institutions, [and] (3) in laws. The river Garonne divides the Gauls from the Aquitanians; the Marne and Seine [separate] them from the Belgæ. Of all these the Belgæ are the bravest: (1) they are furthest away from the civilization and refinement of the Province; (2) merchants very rarely visit them and introduce [among them] those [articles] which tend to the deterioration of manliness; and (3) they are nearest to the Germans, who live on the other side of the Rhine, with whom [too] they incessantly carry on war. The Helvetians, from the same cause, likewise excel all the other Gauls in bravery, because in almost daily battles they contend with the Germans, while they (1) either restrain them from [invading] their territories or (2) themselves carry the war into the territories of those [enemies]. One part of those [places], of which it is said the Gauls have possession, takes its beginning from the river Rhone; it is bounded by the river Garonne, the [Atlantic] ocean, and the territories of the Belgæ; it reaches to (touches) the river Rhine from the border marches of the Sequans and the Helvetians. It lies towards Charles' Wain (the north). The Belgæ take their rise from the furthest off territories of Gaul, extend to the lower part of the river Rhine, [and] look towards Charles' Wain and the rising sun (*i.e.* north-east). Aquitania extends from the river Garonne to the Pyrenean mountains and that part of the ocean which looks towards Spain, between the setting sun and Charles' Wain (*i.e.* north-west).

EXERCISES.

(1) The student is recommended to frame a table like that given below, and to insert in it, in their proper columns, all the nouns found in the present chapter, with a note of the speciality of declension (if any) which marks it.

Nouns arranged according to Declension.

First.	Second.	Third.	Fourth.	Fifth.
Gallia. &c.	Initium. &c.	Finis. &c.	Occasus. &c.	Dies. &c.

This tabular form may be more easily employed than the preceding one, but should not supersede its use.

Latin.	English.	Dec.	Gen.	Num.	Case.
Mercatores, . . .	Merchants, . .	3rd	Mas.	Plur.	Nom.
Cultu, ...	Culture, . . .	4th	Mas.	Sing.	Abl.
Bellum, ...	War, ...	2nd	Neut.	Sing.	Acc.

The following form will be found of great use in giving definiteness to our ideas of the nouns we meet:—

[Word quoted] is a noun of the declension, because the genitive case singular ends in ; declined like ; in the number, case, gender; from . It is declined thus:—

Singular—*Nom.* , *gen.* , *dat.* , *acc.* , *voc.* , *abl.* .
Plural—*Nom.* , *gen.* , *dat.* , *acc.* , *voc.* , *abl.* .

(2) Draw out tabular forms similar to those given at p. 702; collect under each form as many sentences as can be found in the foregoing examples, agreeing in being found exactly like them; *e.g.*

I. Mercatores | commeant.
   Belgæ | sunt | proximi.
II. Belgæ | gerunt | bellum.
III. Helvetii | præcedunt | reliquos Gallos | virtute.
   Galli | obtinent | unam partem | Galliæ.
   Garumna flumen | dividit | Gallos | ab Aquitanis.

PHYSIOLOGY.—CHAPTER IX.

RESPIRATION: PURPOSE, MECHANISM, CHEMISTRY, RESULTS, AND ABNORMAL PHENOMENA OF BREATHING.

Breathing is the operation by which the blood is aerated or arterialized. The blood, that it may be an agent of life and health, must be pure. As we know, the waste matters of the tissues of the frame are taken up into it in its passage through the body; it follows that, if it is to be purified, some means must exist by which these waste matters may be discharged from the nutrient fluid. The forms in which the products of decomposed tissues appear are carbonic acid, urea, and water. The lungs are the chief eliminators of carbonic acid from the blood. That acid extinguishes flame and suffocates living creatures. Hence miners call it choke-damp. It is well known that men entering into places where there has been concealed fire, or such as are full of the products of fermentation or putrefaction, are greatly in danger of suffocation, and that preliminary precautions are usually taken before going into any confined place where there has been little or no circulation of air. It is on this account that men introduce a lighted candle into any place, well, cavern, &c., in which there

has not been an active circulation of air before they themselves enter it; for they know that if the flame of the candle is put out, it is because there is carbonic acid there, and that it would be injurious, even fatal, for them to breathe it. A candle will only burn brightly and steadily in good air, and men can only breathe healthily and pleasantly in a thoroughly pure atmosphere. It is absolutely necessary for the proper maintenance of life that we should breathe adequate quantities of pure air—air fit for effecting those changes in the blood which renew its nourishing powers—*i.e.* capable of transforming the dark purple-coloured *venous* blood, charged with the waste products of the body, into the bright-red *arterial* blood, which carries in it briskness and life, health and energy. It is in the lungs that this restoration, as we may call it, of the blood takes place.

Carbonic acid has the effect of extinguishing life when the blood gets overcharged with it. In the living body it forms in considerable quantity and is absorbed into the blood. The blood is brought into the lungs in order that the poisonous matter with which its streams have become contaminated may be purified, sweetened, and reoxygenated. In a normal atmosphere carbonic acid is diffused in the proportion of four parts in 10,000, and just as this quantity is increased in the air the less wholesome it becomes, the less refreshing, and the more dangerous. Every one knows how different the feeling of life is in the fresh air of the country from that in the dense carbonized air of a large town. The importance of pure air, and the proper arterializing of the blood, may be impressed upon us by the statement of the fact, that speaking in round numbers, and on a general average, an ordinarily-sized healthy person consumes in a year 100,000 cubic feet of air, and employs that in purifying 3500 tons of blood.

Besides carbonic acid, the lungs give off moisture in the watery vapour we call breath. This moist air carries in it a variable quantity of waste organic matter, the decomposed material of the tissues. The matter, unless dispersed by free diffusion in the air, has a tendency to become unpleasant and unwholesome. Because it is noxious when it accumulates, it has a fetid, stuffy smell, and thus we know that the air in which it is largely present is not properly fitted for being re-breathed. It is the breathing of such air in overcrowded or small ill-ventilated rooms which causes the listless drowsiness often felt in them, because the atmosphere then gets overcharged with those waste products which the lungs (and the skin) are constantly pouring into it. Each tissue has its own function and properties, and each tissue in its decay communicates its waste and worn materials to the blood, that they may be ejected from the system in some way or other. By the vaporous and liquid exudations of the skin—in the forms both of sensible and insensible perspiration—chlorides of sodium and ammonium, phosphates, and several other salts, and a considerable quantity of organic waste, are carried off. Other waste products of the tissues of the frame, various at once in quantity and composition, but all prone to putrefaction, are carried off by the kidneys. Breathing, however, is the chief operation in the regenerative chemistry of life. Breathing, by introducing atmospheric air into the body, provides for the importation into the blood of that special element which possesses the largest range of affinities for other elementary substances, and exerts the most active and various energy in entering into combination with them—namely, oxygen. It occurs in all the fluids and tissues of vegetables and of animals. Without it life cannot be supported. Respiration is the process by which this "vital air" of the older chemists is brought into such relations with the blood as to remove from it waste and injurious matters, and restore its invigorating power.

If we regard air as a bodily food, and breathing as a constant feeding on air, we shall at once see the importance of having every breath we draw fresh, pure, and wholesome, and therefore of attention to ventilation, and to the choice, where possible, of a residence in a clear, untainted atmosphere. We eat and drink only a few times a day, and then we like to have everything nice and clean—entirely free from adulteration. But the lungs require to be supplied with air continually. All night and all day we must go on breathing, and with every inspiration—*i.e.* on an average every three seconds—we fill the lungs with air which is to be immediately employed in the organic processes of the frame. Of this air we inspire about 500 cubic inches per minute, and there are from three to four beats of the heart made for one act of respiration. As each beat of the heart sends about an equal quantity of blood for purification into the lungs, so each inspiration introduces nearly a similar quantity of breath to aerate it. The whole of the blood in the body passes once through the bloodvessels and the lungs in about two minutes, and it is thus brought into relation with a very large amount of vital air in its progress through the spongiose pulmonary cellular tissues. The cellular membranous sacs, so numerously diffused in the lungs, are exceedingly delicate—less even than the 26,000th part of an inch in thickness; and the capillary tubes through which the blood is conveyed—inclosing these air-cells in a network like that surrounding a child's air-filled india-rubber ball—are of the finest and most minute kind, being less in diameter when cut transversely than the 200,000,000th part of a square inch. Only separated from these delicately-vascular tubes by those moist partitionary membranes, the inspired atmosphere, thoroughly diffused through all the cells, brings to the blood the oxygenation it requires, and the expired breath carries out from the frame at once the carbonic acid and the lung transpirations into the environing atmosphere. This fouling of the atmosphere occasions the need for thorough ventilation, free circulation of the air.

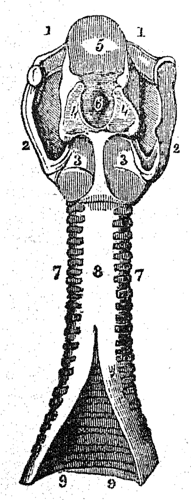
The special physiological purpose effected by respiration is twofold. It provides (1) for the introduction into the living frame of such an amount of oxygen as is requisite to transform the waste products of the tissues—muscular, nervous, membranous, &c.—into new compounds with itself, which may be readily and easily excreted, *i.e.* removed from the body by the special organs to which that duty is allotted—the lungs, the kidneys, the skin, &c.; and (2) it supplies the means by which carbonic acid, the most deleterious of the elements resulting from the operations of the chemistry of life, may be speedily and directly discharged without opportunity, in a healthy system, of accumulating and effecting injury. The incoming of oxygen and the outgoing of carbonic acid are both accomplished by the process of breathing. In the *air* which leaves the lungs oxygen is diminished, and carbonic acid increased; but in the *blood* which leaves the lungs oxygen is increased and carbonic acid diminished. From 100 volumes of blood 60 volumes of gas can, under the action of the mercurial air-pump, be extracted. The change effected in these volumes by breathing may be tabulated thus, on the authority of Dr. Michael Foster—

	Oxygen.	Carbonic acid.	Nitrogen.
Venous blood,	8 to 12 vols.	... 46 vols.	... 1 to 2 vols.
Arterial blood,	20 "	... 39 "	... 1 to 2 "

Breathing is the function of those special organs, the lungs, by which, through the trachea or windpipe, the outer air can be brought into the interior of the chest in such a state that not only is the pure air taken in and used for the freshening of the blood, but the vitiated contents of the venous blood are carried away and got rid of. The lungs may be regarded as a pair of conically-shaped elastic membranous bags, the broad base of each of which rests on the muscular midriff or diaphragm, while their narrowing mouths convergingly rise towards the neck where the primary bronchial divisions of the windpipe enter at what may be called the lung-root, and bring their supply of air into the bronchi (bronchial tubes), to be conveyed through the whole of the lobules and air-cells of their fabric. We may liken them, roughly speaking, and in this particular relation, to a double pair of bellows (of which the membranous sacs may be regarded as the bodies), having two meeting orifices in the bronchi, opening into a single outlet and inlet, called in its lower part *trachea*, and its upper *larynx*, and known in common language as the windpipe (fig. 1). These double-bodied bellows are suspended in the chest by the trachea, and separated from each other by the mediastinum. By their alternate dilations and contractions, the outer air of the atmosphere is brought within the body, and, when its regenerating effect has

been wrought there, is expelled in order that the frame may be again replenished with oxygen and displenished of carbonic acid and other deleterious matters. When the lungs, in the exercise of their breathing activity, distend, the respirable air which surrounds us at once streams in and pursues its way through all the bronchial ramifications; when, by physical reaction, the elastic textures of the muscles relax, and the thoracic cavity is narrowed in extent, the breath is discharged from the air-tubes and forced through their only available aperture into the outer air again.

Fig. 1.



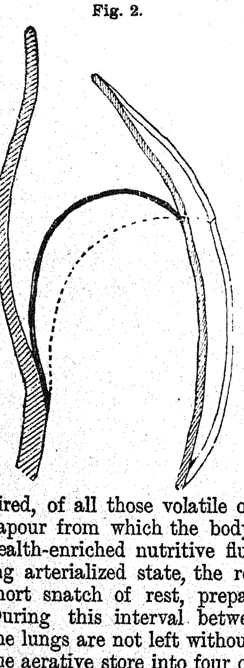
Section of the Larynx.

1, 1, Os Hyoides; 2, 2, Thyroid Cartilage; 3, 3, Cricoid Cartilage; 4, 4, Arytænoid Cartilages; 5, Epiglottis; 6, Aperture of communication between Glottis and Pharynx; 7, 7, Rings of Trachea; 8, Situation of transverse posterior Muscular Bands; 9, 9, Portion of Trachea (windpipe) cut open from behind.

This alternate action, the increasing and decreasing of the area of the lung-sacs, constitutes respiration. The aim of this expansion of area is to bring under the action of the most extensive attainable surface of air the largest possible surface of blood. In the highly developed lungs of man, the more thoroughly the air penetrates and interfuses the bronchial ramifications, lobes, and sacs, the larger the surface with which it is brought into contact, and on which it can operate. The extent of possible surface to which the pulmonary apparatus affords access may be approximately represented to the mind as a square showing a side of 12 feet. From this estimate the readiness and the amount of interchange of gases may be brought somewhat within the reach of conception.

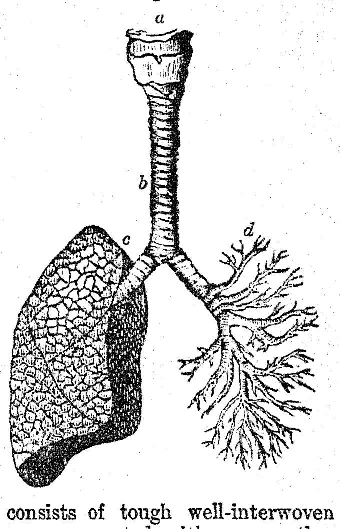
Each act of respiration involves mechanically four distinct elements—(1) an inspiration, (2) a brief interval, (3) an expiration, and (4) a pause, amounting in duration to nearly one-fifth of the time employed in the entire process. Supposing at this latter point that the diaphragm attains a position of rest. It then forms an arch, convex towards the thorax or chest, something like an umbrella shot up (see fig. 2). When it contracts, it becomes flatter, as shown by the dotted line, and the thorax gains that space for inspiratory purposes. The ribs and the more elastic of the cartilages which lie between them are capable of simultaneous movement with that of the diaphragm, and they also increase the thoracic area to allow for the inflation of inspiration. For a brief interval the equilibrium of the antagonistic forces of muscular fixation and movement, of inner and outer pressure, supplies the opportunity for that interchange of gases in the lungs by which a bright scarlet colour is imparted to the vitiated dark-red blood of the venous circulation. Then comes the active exertion of exhalation, for the removal, in the air expired, of all those volatile organic matters and that watery vapour from which the body needs to be freed. While the health-enriched nutritive fluid flows onward in its refreshing arterialized state, the respiratory muscles have again a short snatch of rest, preparatory for a renewal of effort. During this interval between inspiration and expiration the lungs are not left without air. Physiologists distinguish the aerative store into four quantities—(1) *tidal* or breathing air, that ordinary volume of air which passes in and out in each several act of respiration while inhaling and exhaling normally; (2) *residual* or funded air, a certain quantity of air always left behind in an act of breathing, forming a sort of store with which the chemistry of reparation can be carried on till new and fresh supplies are introduced, when the residual store, vitiated by its stay in the lungs and the heat it has absorbed, finds its way into the outer air at some succeeding tidal expiration; (3) *supplementary* or surplus air, so much of the volume of inhaled air as may be retained in the chest in the course of tranquil breathing, not actually required in the normal activity of the oxygenating process, but which may in an exigency be found useful, and which can be displaced at will; (4) *complementary* or redundant air, that amount of air which can be inspired on occasion in addition to the ordinary normal requirements of the body, and can be introduced into the lungs by an effort of will which inflates to their maximum stretch the whole contents of the pulmonary spaces. The total amount of our respiratory power receives the technical designation of vital capacity. It may not be amiss to note here the great advantage of the residual air. If the breath received in one respiratory act were exhaled at once, the time allotted to the operation of the pure air on the impure blood would be too short, and the number of respirations would require to be greatly increased. But by the operation of the residual air economy of respiratory activity is greatly promoted.

Fig. 2.



Of the respiratory organs, the lungs, fig. 3 presents a view, including the larynx, *a* (also shown in fig. 1), the framework of which is composed of five cartilages capable of being moved upon each other in various directions by muscles, and takes the form of a pyramid whose base is placed upmost, having the epiglottis as the leaf-like covering of its opening, and being itself continued into the rounded tube of the trachea, *b*, which begins a little above the upper edge of the breast-bone. The front and sides of this air-passage are composed for the most part of cartilage, forming nearly three-fourths of a ring about the eighth of an inch in diameter, while the remaining fourth, that is, the back part, consists of tough well-interwoven elastic tissue. The rings are connected with one another by muscular and cellular fibres, and the whole inner walls of this cartilaginous and membranous tube is lined with delicate mucous coating whose fine epithelium consists of cells from which vibrating cilia project. From the larynx to the chest the trachea descends as a single tube till it reaches the level of the third dorsal vertebra, and there it divides into two main branches called the *bronchi*, one of which goes to the right and the other to the left. The former of these is wider, shorter, and rather sharper in its angle of deflection than the latter. Of the right lung, *c*, under the divarication of the bronchi, we present an exterior view. The indent on the outer line shows where it is divided into lobes—of which the left lung (that space may be given to the heart) has two and the right has three. The shaded division seen in the upper part indicates where these lobes are divided into lobules. The right bronchus is represented as denuded of its lung-tissue, and the figure exhibits the arborescent ramifications which the bronchial tubes, *d*, take through the vascular network of the pulmonary mass till they terminate in closed vesicles, each of which incloses in its recesses clusters of air-cells. So thoroughly is the entire tissue of the lungs permeated with minute air-canals leading to these vesicular centres of clustered air-cells, that, as physiologists reckon, not less than 600,000,000 of these

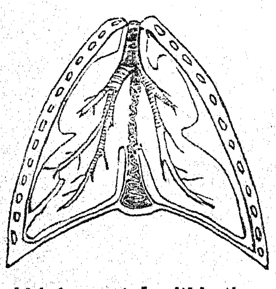
Fig. 3.



terminal air-cells—consisting of mucous membrane interwoven with elastic yellow fibre—are massed together in the lungs of an average adult. In the upper part of the bronchus only the larger bronchial tubes are shown; but in the lower portion the more minute and delicate bronchi are traced till, at about an eighth of an inch from the cells to which they carry their air-freight, they are filaments too fine to be represented by the draughtsman's skill. As a mode of suggesting to the mind, by some analogue, the way in which these lung-vesicles, partitioned off as they are one from another, are yet all separately supplied with their due proportion of air, they have been likened to a bunch of grapes—the stem, the branches, and the separate grapes of which are each hollow. The grapes, however, require to be thought of as being a collection of little cells, small as millet-seeds, set on a footstalk, each footstalk being a tube, and each tube being again only a sub-pipe to the main-pipe or bronchus, through which they all receive inflation, and along which, each, on the contraction of the walls of the chest, gives forth its airy contents.

The annexed woodcut (fig. 4) represents the chest laid open, with the lungs resting on the diaphragm, and shows how the trachea divides into bronchi, ramifies through the pulmonic mass, and indicates the lobed structure of each lung. The thin, smooth, membranous sac, called the *pleura*, which invests with one layer the entire mass of the lungs except where the windpipe and bloodvessels enter them, and with the other layer lines the interior walls of the chest, is indicated by the leaf-like outline of the lung. In order that in the act of breathing these two layers may permit any necessary gliding motion of the lung-sacs within the cavity of the chest, a thin serous fluid, similar to that which is secreted within the pericardium, is formed between the pulmonary pleura and the costal or chest-lining pleura, and lubricates their inner surfaces. The inflammation of these membranes is called *pleurisy*.

Fig. 4.



The air-food which we have such a capacity for receiving, and are under such a continual necessity of inhaling, consists, prior to inspiration, of 79 per cent. of nitrogen and 21 per cent. of oxygen, and is but slightly tinctured, in a proper state, with carbonic acid. On its expiration, however, while the nitrogen is not perceptibly altered in quantity, the oxygen is found to be reduced to 16 or 17 per cent., and the place of the oxygen is found to be occupied by 4 or 5 per cent. of carbonic acid. This is not the only change which has taken place in the atmospheric air. As water vapourizes at almost any temperature, and diffuses itself through the air we breathe, inspired air, therefore, contains a slight quantity of watery vapour in it. On expiration, however, the air is not moist-laden only, but saturated with vapourized water. When air enters the lungs it may vary considerably from the temperature of the body, but on being exhaled it is generally found to approximate pretty closely to blood-heat, and it also carries with it a small quantity of more or less thoroughly decayed animal emanations, called by physiologists pulmonary transpirations. When we have breathed pure fresh air we feel exhilarated and revived; a sense of livingness and power is manifest in the entire frame. When this renewal of the airy currents cannot be promptly and constantly obtained, terrible uneasiness, pain, distress, and anxiety speedily inform us of the absolute necessity of regular and fitting supplies of this inestimably precious life-fluid. By a general law of nature gases and liquids have a special facility of diffusion. These particles gradually disperse among one another or through any solid capable of holding them in its pores. In this way noxious gases and vapours are dissipated through the free open air, and are prevented from accumulating in injurious quantities by this mutual interpenetration of the one by the other. This diffusion, or rather transfusion, of fluids and liquids is possible, not only in free currents, but in cases where different substances of this sort are separated from each other by a membrane. This transfusion of unlike liquids through intermediate tissue in a more or less developed vascular system is called *osmosis*, and the distribution thus accomplished is said to be due to osmotic action. The nutritive exchange of oxygen and carbonic acid through the moistened membrane of the air-cells and the capillary network which surrounds them seems due to some form of osmotic action, though the exact mode of its operation is not yet explicitly determined by scientists. We have, on the one side, a globule of inspired air brought, not exactly into contact, but into osmotic relation with a particle of venous blood. Instantaneously there occurs a notable change. The blood, conveyed by the pulmonary arteries and passed slowly through tubes of continually increasing fineness, appears in the capillaries black, thick, heavy, laden with innutritious elements and with excremental products gathered together in its circulatory transit through the body. It conveys in its mass serum, lymph, and carbonized matter. The outer air comes into relation with it. At that very moment this dark venous blood is decomposed, and bright-red blood flows in its place. That part of it which had subserved the various purposes of life—and in doing so had not only parted with its good qualities but taken into itself substances of a deleterious character—has been purged. It is now brisk, sparkling, and nutritive. Thus the blood has been transformed in its passage through the lungs, and carries with it a freight of reviving energy, and gathering together again into the pulmonary veins their regenerated streams, pours them into the heart, that by its force the sanguine fluid may bear health and vigour through all the arteries. Meanwhile, in the air-cells of the lungs, heat, moisture, organic matter, and carbonic acid have permeated the breath. Rarefied by the heat and having dissolved the used-up moistening mucus of the cellular cavities, the air is ready to rise and seek an outlet for itself; but just then the diaphragm rises, the ribs contract, the spongiose pulmonary mass is subjected to pressure, and the breath is expelled, carrying with it into the atmosphere the vapour, the organic matter, and the carbonic acid with which it is charged, to be mixed with and to be diffused in the gaseous matter surrounding the globe. It is evident that this breath is not fit for respiratory purposes, and ought not to be returned into the lungs by rebreathing, but should be allowed free opportunity of diffusing itself, as, in consequence of being heated, it has a tendency to do, into the free open air. It must be recollected, too, that the damp organic matter outbreathed by the lungs is apt to settle down upon and adhere to any clothing or furniture which affords an opportune resting-place, and therefore that rooms not freely ventilated must become stuffy, disagreeable, and unwholesome.

The *hæmoglobulin*—a compound of *hæmatin* and *globulin*—of the red corpuscles of the blood has absorbed the oxygen, and is prepared to carry it, in loose combination, to those tissues of the frame in which previous supplies have been used up. The blood plasma takes up the effete transformations as carbonic acid in simple solution, ready to be given off when the opportunity of exchange occurs.

The following are some of the more or less abnormal phenomena of the respiratory processes:—

Coughing is a brisk, harsh expiration. It produces a striking, sharp, clicking noise; sweeps the bronchial tubes and the throat, and carries away from them the mucus which constitutes the cause of irritation. It is the result of a feeling of uneasiness or irritation—chemical or mechanical—in some part of the air-passages.

Sneezing or *sternutation* is a sudden expulsive and explosive act of expiration almost wholly confined in its operation to the nose, the passages of which it sweeps. This is an involuntary act arising from some irritation of the soft palate or the membranes of the nostrils, and is often accompanied by spasmodic contractions of the muscles of the face.

Sighing is a deep, gentle outbreathing occurring at intervals, arising sometimes from moral and at other times from physical causes, when, for instance, one is depressed with sorrow or is inhaling air which has been impoverished of its

healthy elements. Its aim seems to be to clear out a larger quantity than usual of the residual air, that a greater amount of quickening and enlivening breath may be introduced to the venous blood so as to reinspirit the circulation.

Yawning is a slow, deep, and semi-involuntary breathing, accompanied by a great widening of the jaws, producing a peculiar facial expression, and followed by a gradual, gentle expiration, which makes a dull, half-sighing sound. It indicates want of sleep or of interest in one's employment, and expresses a feeling of outworn weariness.

Hiccough arises from a spasmodic contraction of the diaphragm, the convulsive action of which induces an abnormal jerky entrance of air, and sometimes coincidently originates contractions of the lips and vibratory constructive motion in the glottis. It is an indication and a result of nervous disorder.

Sobbing is a disturbed respiratory act arising from the convulsive and jerky contraction of the diaphragm, by which the sound produced by the glottis and lips are made intermittent. It is often an accompaniment of weeping, and may be due either to lively emotion or to sorrowful feelings.

Laughter consists of a succession of short, jerky, noisy expirations following upon a deep, strong inspiration, and exciting a gay expression of features. The resonance is caused by the vibration of the vocal chords and the impulsive action of the soft palate. It affects at once the face, the throat, the thorax, and the abdomen with its peculiar agitation—often suddenly and irresistibly. It not only causes muscular motions of the mouth and face, but frequently, by the rapid recurrent explosions of the breath, shakes the sides and even the whole frame. It is a common manifestation of hysteria, and seems to be intended to effect in some way a redistribution of nervous power.

Stertor or *snoring* is a heavy audible form of breathing arising from the air-currents flowing through the nostrils and the mouth at the same time, and so causing a vibratory motion of the soft palate. It arises, physically, as in the stolid sleep of outdoor labourers, from overwrought fatigue, and the need for large supplies of restorative air; from some impediment to the regular and rapid circulation of the blood in cases of paralysis; and from the blood, as in the case of gas-poisoning, &c., being overcharged with deleterious or effete matter, for the getting rid of which increased quantities of fresh air are urgently required. Snorting is a sudden expulsive act, or series of acts, of expiration through the nostrils—sometimes amounting to a sort of intermittent snoring.

When the respiratory organs are in a healthy condition two sounds readily distinguishable from each other may be heard by applying the ear, either directly or by the aid of the stethoscope, to the chest. The first, which may be best heard by applying the ear or the stethoscope to the chest immediately below the collar-bone, is called the respiratory murmur or the vesicular sound. It is so called because it is regarded as the sound caused by the passage of the air from the arborescent bronchial tubes to the vesicular air-cells. It is observable chiefly during inspiration, and is very faint in expiration. Thin people generally give forth a more audible sound than those who are fat, women than men, and children than adults. It is less a murmur than a gentle rustling resonance, or swish, like that made by the air in passing through the leaves of a tree. The second, which may be most distinctly observed just on the windpipe or at the upper part of the breast-bone, is called the bronchial sound. It has a blowing tone, such as is made by breathing through any long tube in a slow deliberate way, and quite clearly suggests the passage of breath through the main air-passage of the lungs. These are, of course, modified in any diseased condition of the pulmonary structure. The murmur may be weakened in one part and intensified in another; and the bronchial sound be made more or less inaudible by the thickening of the pulmonary textures or by the dilatation of the tubes. In diseased states of the lungs a sibilation or wheeze, technically a *rhonchus*, is heard. It is of two sorts—(1) the *dry* sibilation, occasioned by the passage of air through the bronchial tubes unduly narrowed or compressed, and (2) the *moist* whizzing or rattle caused by the formation of bubbles of greater or less tenacity as the air passes through fluid matter collected in the air-channels. A quick, sharp, tinkling metallic sound, similar to the striking of a pin on a piece of glass, shows that an inclosed hollow containing air has been formed in the lungs. A sound resembling that made by rubbing or friction indicates that the *pleura* are roughened by inflammation, and that pleurisy has set in.

We may sum up and epitomize the contents of this chapter in the following form:—

Respiration is the act of breathing, and its *result* is the reinvigorating of the blood. The *functions* of respiration are either (1) normal, as breathing, or (2) abnormal, as coughing, &c.

The *organs* of respiration are (1) external, (*a*) the bones, and (*b*) the muscles of the chest; and (2) internal, (*a*) the throat, (*b*) the lungs, and (*c*) the diaphragm.

The lungs comprise—besides the connective tissues, in which they are inlaid—(1) the bronchi, (2) the bronchial tubes, (3) the vesicles, and (4) the air-cells.

The *act* of respiration involves four processes—(1) inspiration, (2) interval, (3) expiration, and (4) a pause.

The *process* of respiration consists in (1) the introduction of atmospheric air into the system, (2) the oxygenization of the venous blood, and (3) the transference from the body of (*a*) waste matter, (*b*) watery vapour, (*c*) heat, and (4) carbonic acid.

For the proper fulfilment of the respiratory process we require thoroughly healthy and well-exercised lungs, a sound and efficient circulatory system, both systemic and pulmonic, besides an adequate and constant supply of pure, wholesome, easily respirable air—neither too dry nor too moist, and of a medium temperature.

It is advisable in a changeable climate such as ours, to improve and strengthen the respiratory organs by exercise and culture. Conversation, singing and reading, gymnastic recreations, and regulated walking are highly useful for these purposes; but especially in early youth the systematic exercise of the lungs in breathing regularly and definitely, so as to acquire as complete a control of the will over the process as possible, that we may adapt lung-power to exertion, will be found conducive to sound pulmonary activity. By learning to breathe through the nose, in which there is a large expanse of surface freely supplied with warm blood, we might often do much to regulate the temperature of the air before it enters the lungs, while by avoiding, or at least reducing to a minimum, conversation on cold nights, especially after leaving heated rooms, we might save ourselves from many serious affections of the throat and lungs.

BOOK-KEEPING.—CHAPTER VIII.

PRACTICAL INSTRUCTIONS AND EXAMPLES—TRANSACTIONS.

Our instructions have had for their object to lead up to the practical result of enabling the student to see the principle upon which book-keeping is based, and that it prevailed throughout the whole processes of every system. This was done by showing the operation of this principle in a series of analytical examples, embracing the chief accounts required in trade. We believe that now we may venture to bring the learner face to face—as nearly as an imaginary set of books may do so—with real business, and employ him in tracing through a more systematic series the course of the different items occurring in a definite series of transactions. In the case before him he will find the history of the business of William King for one month stated in detail. He will find, on the left hand—arranged like so many marginal references—the letters C.B., D.B., and I.B., respectively signifying Cash Book, Day Book, and Invoice Book. These indicate the books to which each of the entries is to be transferred. On reference to the descriptions, definitions, and examples of these books in our previous chapters the learner will see on what ground this distribution has been made, and know the reason for the course adopted with each. He will have an opportunity given him of tracing these same entries to their respective places among the entries of these books, and of observing their conformity, as entries, with the principles which he has been taught, and so have a clear and practical

illustration of the real relations of business transactions to each of these books. So far, through these imaginary commercial operations, he will be able to thread his way and have represented to him, in concrete examples and definite working order, the ordinary processes by which the transactions of business are classified, arranged, and recorded—as regards these transactions—by single entry. He will hereafter be shown how the other books and accounts come into use and are managed, and specimens of book-keeping by double entry will follow, so as to give a complete theoretical exposition and practical exemplification of the whole subject.

On the right hand the inner cash columns contain the details (which the student should sedulously verify), and the outer cash columns exhibit the totals of the several separate transactions—the summation of the individual groups, which the student should carefully scan.

BLOTTER:—THE TRANSACTIONS OF WILLIAM KING, EDINBURGH.

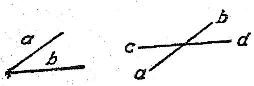
1888.	Jan.		£.	s.	d.	£.	s.	d.
C.B.1	1	William King commenced business with				1500	0	0
C.B.1	"	Paid into National Bank of Scotland (Limited), ...				1000	0	0
C.B.1	"	Stock at time of taking over business, for which paid cash,				350	0	0
D.B.1	3	Sold to John Reid, Edinburgh,						
		6 bundles lead pipe,						
		Cwts. qrs. lbs.						
		9 1 14 at 15/,	7	0	7½			
		2 shts. lead, 20 2 0 " 14/,	14	7	0			
		1 cask putty, 1 0 14 " 9/,		10	1½			
		white lead, 2 0 0 " 22/,	2	4	0			
		2 gallons varnish, . " 10/6,	1	1	0			
						25	12	9
C.B.1	"	Bought goods for cash, . .				25	10	0
D.B.1	4	Sold to Charles Smith, Leith,						
		Ton. Cwts.						
		1 10 nails at 10/3 per cwt.	15	7	6			
		40 shelf brackets at 5½*d.*	0	18	4			
		2 kitchen ranges " £7 10/	15	0	0			
D.B.1	5	Bought from Robert Wilson, Birmingham,				31	5	10
		30 hall lamps at £3 5/,	97	10	0			
		25 wall brackets at 17/,	21	5	0			
		19 stew pans . . " 2/6,	2	7	6			
		12 grates . . . " 22/,	13	4	0			
						134	6	6
C.B.1	6	Bought goods for cash, . . .				17	0	0
C.B.1	"	Sold goods for cash, . . .				72	9	0
C.B.1	"	Paid trade expenses—postage and receipt stamps, . . .				1	0	0
C.B.1	7	Paid into National Bank, . .				40	0	0
D.B.1	9	Sold to John Coutts, Glasgow,						
		Cwts. qrs. lbs.						
		12 casks grease, 19 3 14 at 3/2,	3	2	11¼			
		6 doz. penknives, " 18/,	5	8	0			
		14 sets tiles, . . " 3/6,	2	9	0			
						10	19	11¼
I.B. 1	12	Bought from Thomas Graham, George Street,						
		100 squares glass, 3′ × 2′ at 3½*d.* per foot, ...	7	5	10			
		40 flower pots, 14″ at 1/2,	2	6	8			
		10 garden vases " 14/,	7	0	0			
						16	12	6
	14	Granted him bill at 3 months,				16	12	6
	"	Bought from J. Innes, Dumfries,						
		20 tons manure in bags at 18/,	18	0	0			
		200 bags . . . . " 1*d.*	0	16	8			
						18	16	8
D.B.1	15	Drawn from National Bank, .				25	0	0
		Sold Wm. Miller, Dalkeith, 12 Exhibition tablecloths at 21/,	12	12	0			
		Yds. ft. in.						
		2 pieces linoleum, 14 2 6 at 2/9 per yard, . . .	2	0	9½			
		1 bedroom suite, ...	31	0	0			
I.B. 1	18	Bought from Theodore Horne,				45	12	9½
		London, goods as per invoice,				22	10	6
D.B.1	"	Sold to Samuel Johnston, Maitland Street,						
		Cwts. qrs. lbs.						
		14 chests tea, 15 2 7 at 2/8,	232	8	0			
		1 brl. sugar 6 0 14 " 3*d.*	8	11	6			
		Barrel, ...	0	6	0			
		Cwts. qr. lbs.						
		10 cheeses, 4 1 16 at 10*d.*,	20	10	0			
		2 doz. pickles " 8*d.*,	0	16	0			
		2 cwt. white soap " 9/,	0	18	0			
		1 doz. champagne " 10/6,	6	6	0			
						269	15	6

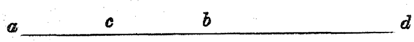
1888.	Jan.		£.	s.	d.	£.	s.	d.
D.B.1	18	Sold to James Jackson, Newhaven,						
		6 doz. silver forks, at 12/6,	3	15	0			
		4 " table knives, " 7/,	1	8	0			
		6 " teaspoons, " 6/6,	1	19	0			
		1 China tea set, " 45/,	2	5	0			
						9	7	0
I.B. 1	19	Bought from George Simpson, Dumbarton,						
		15 pair steps, at 14/, . .	10	10	0			
		2 long ladders, " 25/, . .	2	10	0			
		24 pails, " 2/6, . .	3	0	0			
						16	0	0
C.B.1	21	Paid him cash, ...				16	0	0
C.B.1	"	Received from him Discount, .				0	10	0
C.B.1	"	Received from John Coutts, Glasgow, to account, . . .				10	0	0
C.B.1	"	Paid into National Bank, . .				7	10	0
D.B.1	22	Sold to Peter Stevenson, Argyle Street,						
		3 iron gates, at £1 5/,	3	15	0			
		12 clothes posts, " 5/6,	3	6	0			
		17 squares glass, 3 × 2, at 4½*d.*,	1	12	8½			
						8	13	8½
C.B.1	"	Received from William Miller, Dalkeith, ...				45	12	9½
	"	Allowed him Discount, . . .				0	12	9½
I.B. 1	23	Bought from John Henderson, Princes Street,						
		1 gross horse shoes, at 9*d.*	5	8	0			
		Cwts. qr. lbs.						
		2 bars iron, 3 1 7 at 3/,	0	9	11¼			
		1 dozen files, at 1/3, . .	0	15	0			
		25 yards machinery belting, at 2/4, ...	2	18	4			
						9	11	3¼
	"	Sold goods for Cash, . . .				11	13	0
C.B.1	25	Cash from Mr. Charles Smith, Leith, ...				31	5	10
	"	Allowed him Discount, 2½ per cent., ...				0	15	10
C.B.1	"	Paid into National Bank, . .				30	0	0
C.B.1	"	Paid Trade Expenses—						
		Poor and School Rates, . .	0	16	8			
		Water Duty, ...	0	15	0			
		Railway Carriage, . . .	1	3	2			
						2	14	10
C.B.1	26	Drawn by self for personal expenses, ...				10	0	0
I.B.1	"	Bought from Peter Paterson, Glasgow,						
		2 chests green tea,						
		Cwts. qrs. lbs.						
		2 1 7 at 4/6,	58	5	6			
		1 brl. lard, 4 3 0 " 10*d.*,	22	3	4			
		14 cheeses, 562 lbs., " 1/,	28	2	0			
		3 sides bacon, 47 lbs., " 9*d.*	1	15	3			
						110	6	1
D.B.1	"	Sold to John Brown, Greenock,						
		6 metal teapots, at 7/3,	2	3	6			
		1 doz. pair skates, " 10/6,	6	6	0			
		14 feet gas tubing, " 4*d.*,	0	4	8			
						8	14	2
I.B. 1	27	Bought from William Gray, Inverness, goods as per Invoice, ...				171	5	0
	"	Paid him cash, ...				71	5	0
C.B.1	"	Granted him Bill at 1 month,				100	0	0
C.B.1	"	Sold goods for cash, . . .				62	7	6
C.B.1	28	Paid into National Bank, . .				50	0	0
C.B.1	30	Paid Clerk 1 month's salary, .				6	13	4
C.B.1	"	Withdrawn from National Bank,				100	0	0

GEOMETRY.—CHAPTER VIII.

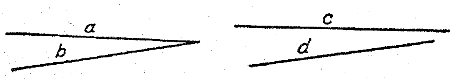
PARALLEL LINES: THEIR LAWS, PROPERTIES, AND RELATIONS.

The relations of straight lines with each other do not, at first sight, seem as if they could involve one in much difficulty. It is obvious at once that two straight lines may exist in two distinct relations—viz. those of (1) connectedness, and (2) separation. Our first idea of a straight line is one that never changes its direction, but maintains precisely the same uniformity of direction however far it may be extended. Lines which are connected must have points or parts in common. They must either (1) meet, as *a* and *b*, or cross one another, as *ab* and *cd*, or (2) be united in a line which contains, includes, and is part of each of them, and this part they have in common, as in

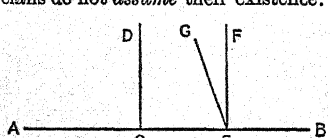


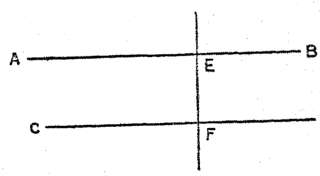


the straight lines *ab*, *cd*, forming together the one straight line *ad*, and having the part *cb* common to *ab* and *cd*. Two different straight lines may have either (1) different, or (2) the same directions. Those straight lines which



meet one another, as *a* and *b*, have different directions, and any two straight lines which have different directions would meet if produced sufficiently far, as *c* and *d*. Two straight lines which are not in the same straight line, and have no parts in common one with another, but have the same direction continuously, and however far they are lengthened always go on side by side, not only never meeting, but never being any nearer or any further apart, are called *parallel straight lines.* Any two such lines as, however far they may (or may be imagined to) be prolonged, never do or can make any approach towards each other, or depart further from each other, cannot meet so long as they each continue to hold on their course undeviatingly. Throughout their whole length, therefore, they must be at each several point equidistant from each other. Two straight lines are said to be equidistant one from another when, any two points whatsoever in the one which is not the greater, and any two equally remote points in the other being taken, the right lines which join each opposite pair of points towards the same hand are equal to each other. Metaphysical geometricians cannot agree upon a satisfactory demonstration of the inevitable accuracy of any (out of the many forms of) definition which has been proposed, because they say that logic demands that definitions should not be based on negations or disjunctions, but ought to state the actual, positive, affirmable qualities of the thing defined. This they regard as a merely precursory definition, not in itself palpable, and not even capable of an obvious demonstration. Probably the nearest possible approach to such a definition may be formally stated thus:—Parallel lines are such as lie in the same plane, and however far they may be produced remain equidistant from each other. Such lines do exist, and we must deal with them. Geometricians do not *assume* their existence: they are real lines. For instance, it may easily be seen (and proved) that any two perpendiculars to any third line are parallel to each other—*i.e.* are (and must be) equidistant from each other, however far they may be extended. For, let A B be a given finite straight line, and C D and E F perpendiculars, drawn respectively (I. 11) from the points C and E in the given straight line A B. Then C D and E F will be parallel one to the other; for if either of them approached nearer to the other or departed from the other, two distinct perpendiculars (as E F and E G) might be drawn from one point and in the same direction, and two straight lines would have a common segment, which is impossible (I. 11, corol. 1, p. 330). It may also be affirmed that two parallel straight lines have common perpendiculars. If A B and C D are parallels, every line drawn perpendicular to one of them, A B, must be perpendicular to the other (or will be so if produced). If the perpendicular E F is drawn to A B through C D, it must cut C D in some point F. At this point F, if a straight line, F C, is drawn, it must (as shown in the immediately preceding theorem) be parallel to E A, and must therefore either be or (which is the same thing) coincide with C F, and E F is a perpendicular common to A B and C D.



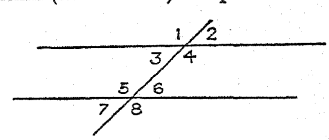


At Proposition 26, with which we last dealt (p. 622), Euclid closes what may be regarded as the first section of Book I. of the Elements. He has discussed in what has gone before angles and triangles—*i.e.* connected lines, and the simplest possible forms resulting from their connection. He now proceeds to consider parallels and parallelograms. This involves definition 3 (p. 55) and axiom 12 (p. 57) of the controversy, regarding which the clear and concise account given by Professor Augustus De Morgan, article "Parallels" in the *Penny Cyclopædia*, is probably the best extant.

We had better here get some definite ideas on the phenomena of parallels.

1. If a straight line falls on and intersects two other straight lines, it makes with each of them four angles—eight in all. Each of these has received special names.

2. The four angles within (*i.e.* between) the parallel lines —3, 4, 5, and 6—are called *interior* angles, and the four which are outside of (or beyond) the parallel lines—1, 2, 7, and 8—are called *exterior* angles.



3. Those angles which hold the same relation, each to each, to the respective lines, are *corresponding* angles—1 and 5, 2 and 6, 3 and 7, 4 and 8.

4. Those angles which are on opposite sides of the intersecting line—3 and 6, 4 and 5—are called *alternate* angles.

5. The angles formed at one parallel line are said to be opposite to those formed at the other parallel, and are also sometimes named *opposite* angles, 1 and 5, and 2 and 6.

Any two parallel lines may be considered, in everything that relates to angles, as one and the same straight line, and any angle may be considered as transferred from one parallel to another (and indeed from any one position to any other position), so long as the lines containing the angle retain precisely the same directions as before the removal of the angle.

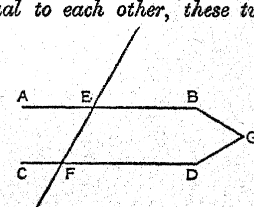
Alternate interior angles are equal to one another; alternate exterior angles are equal to one another; corresponding and opposite angles are equal to one another; and when these pairs of angles are so found equal, the two straight lines which are cut by a third are *parallels.* These statements are respectively proved hereafter.

The first truth which Euclid undertakes to demonstrate regarding parallels is given in the following theorem, and appears as

Proposition XXVII.

If a straight line, falling on two other straight lines, make the alternate angles equal to each other, these two straight lines shall be parallel.

1. Let the straight line E F, which falls upon the two straight lines A B, C D, make the alternate angles [*i.e.* the two angles which two straight lines make with another at its extremities, but upon opposite sides of it] A E F, E F D, equal each to each. Then A B shall be parallel to C D.



2. If they are not they will meet at one or other of the extremities. Let them be produced so as to meet at G.

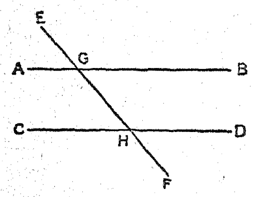
Then G E F forms a triangle, and its exterior angle A E F is greater than the interior and opposite angle E F G (I. 16). But by hypothesis A E F and E F G are equal. They cannot be both, and therefore the lines A B and C D do not meet.

3. The same process repeated shows they cannot meet towards A and C. Now, lines which, however far they may be produced, do not meet are parallel, and therefore A B is parallel to C D.

Proposition XXVIII.

If a straight line falling on two other straight lines make (1) *the exterior angle equal to the interior and opposite angle on the same side of the line, or* (2) *the interior angles on the same side together equal to two right angles, the two straight lines shall be parallel.*

1. Let A B, C D, be two straight lines upon which E F falls, making (1) the exterior angle E G B equal to the interior and opposite angle G H D on the same side of E F, or (2) making the two interior angles B G H, G H D, on the same side together equal to two right angles, then A B is parallel to C D. For, as E G B, G H D, are equal by hypothesis, and E G B equals A G H (I. 15), A G H equals G H D. These are alternate angles. Therefore, A B is parallel to C D. But, again, B G H and G H D are by hypothesis equal to two right angles, and A G H and B G H are also together equal to two right angles; A G H, B G H equal B G H, G H D. Take away the common angle B G H, and A G H equals G H D: they are alternate angles; so that by I. 27 A B is parallel to C D. Q.E.D.

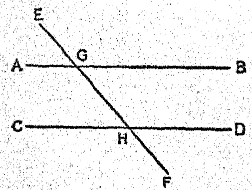


Of the two foregoing propositions Euclid now asks our assent to the *converse*, that is, he now lays before us the conclusion as to the parallelism of two straight lines reached by the reasoning in Propositions 27 and 28 as a hypothesis, that we may test the conclusion resulting from this hypothesis by seeing that it agrees with the conditions laid down and the statements made in the two preceding propositions. It is affirmed now in

Proposition XXIX.

If a straight line fall upon two parallel straight lines, it makes (1) *the alternate angles equal to one another,* (2) *the exterior angle equal to the interior and opposite angle on the same side, and also* (3) *the two interior angles on the same side equal to two right angles.*

Let the same figure show E F falling on the parallels A B and C D. It will make the alternate angles A G H, G H D equal; the exterior angle E G B equal to G H D, the interior and opposite angle on the same side; and B G H, G H D, on the same side of E F, together equal to two right angles. (1) If A G H is not equal to G H D, one of them must be the greater. Let A G H be greater than G H D; add to each B G H. Then A G H, B G H, are greater than B G H, G H D. The two former are together equal to two right angles, and the two latter must be less than two right angles. If so (by axiom 12) A B, C D, if produced, would meet towards B D. As they are parallels they cannot do so; hence A G H is not unequal to the alternate angle G H D—*i.e.* it is equal to it. (2) As the angle A G H equals (I. 15) E G B, E G B equals G H D; add to each B G H, and the two angles E G B, B G H, equal A G H, G H D. (3) Therefore also (I. 13) B G H, G H D, are together equal to two right angles. Q.E.D.

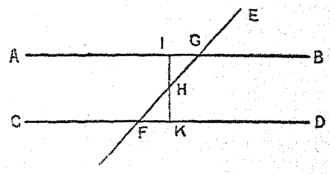


These three propositions might, however, have been all demonstrated as a single theorem in the following general proposition, viz.:—

Straight lines which make equal angles with the same straight line towards the same parts are parallel; and conversely, if two parallel straight lines are cut by the same straight line, they shall make equal angles with it towards the same part.

1. Let the straight lines A B, C D, make with the same straight line E F the equal angles B G E, D F E, towards the same parts; then A B shall be parallel to C D.

Bisect G F in H, and from H draw H K perpendicular to C D (I. 25), and produce H K to meet A B in I. Then because the angle H G I is equal to B G E, and B G E is equal to D F E or H F K, the angle H G I equals H F K. The vertical angles G H I, F H K, are also equal one to the other. Therefore the triangles H G I, H F K, are equal in every respect (I. 5), and so also the angle H I G is equal to H K F (which is by construction a right angle). As was shown in the former of the theorems presented in our preliminary remarks, p. 711, straight lines which are at right angles to the same straight line are parallel, therefore A B is parallel to C D.



2. Let A B be parallel to C D, and let them be intersected by the same straight line E G F; the angles B G E, D F E, which are towards the same parts, shall be equal.

Bisect E F, and draw the perpendicular I K as before; then because I K is at right angles to C D, and A B is parallel to C D, I K is at right angles to A B. Again, because in the right-angled triangles H G I, H F K, the hypotenuse H G and the adjacent angle G H I of the one are equal to the hypotenuse H F and the adjacent angle F H K of the other, the triangles are equal in every respect, so that the angle H G I is equal to H F K; and B G E, which is equal to H G I, is therefore equal to D F E. Q.E.D.

From the foregoing demonstration we get perhaps as near as possible to a trustworthy positive foundation for the definition and doctrine of parallel lines, which would run somewhat thus—viz. Straight lines are said to be parallel when another straight line falling on any two of them makes with them the *corresponding* angles equal (*i.e.* the exterior angle equal to the interior adjacent angle on the same side).

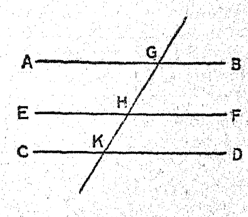
The last of the prelusive theorems regarding parallels prior to testing our apprehension of what we have learned, by setting us to work a problem, occurs as

Proposition XXX.

Straight lines which are parallel to one and the same straight line are parallel to one another.

Let A B, C D, be each of them parallel to E F, then A B shall also be parallel to C D.

Let the three lines A B, E F, and C D, be intersected by G H K; then because G H K cuts the parallel straight lines A B, E F, at G and at H, A G H equals its alternate angle G H F (I. 29). Again, because G H K cuts the parallel straight lines E F, C D, at H and K, the exterior angle G H F equals the interior angle H K D (I. 29). Now, it has been shown that A G H equals G H F, therefore A G H equals G K D, and these are alternate angles (I. 27), so that A B is parallel to C D.



This proposition may be proved even more simply in this way. Let A B and C D be, as before, parallel to E F, they will be parallel to each other; for if they are not they will meet if produced, and there would then be two intersecting lines each parallel to E F, which is impossible (axiom 12), and therefore they are parallel. Q.E.D.

We leave the student to work out the detailed expression of the proposition thus proceeded with as an exercise of his skill in geometrical thought and phrase.

BOTANY.—CHAPTER VIII.

FERTILIZATION OF PLANTS—THE INSTRUMENTS—THE PROCESS—THE RESULTS.

PLANTS are plastic. In them a power exists and exerts itself to give form and fashion to the materials they assimilate. Each has a special economy of its own, in the carrying out of which its several organs take a share. The service which each organ performs is called its *function*. This power of function is concentrated into an atom of matter named a *seed*. Each of these is a storehouse of life. In each there resides a developable capacity, a vital energy fitting it to exercise, under proper conditions, the functions of self-architecture. Thus it is that the seed changes from vesicle to cellule, from cellule to fibre, from fibre to bud, from bud to leaf, from leaf to flower, with all its beauty of bloom and its apparatus for the carrying on of that re-creative and perennial generative force known as reproduction. Each separate plant-form is primarily determined by the kind of matter with which the primordial vesicles, known as the seed, is supplied. The seed inherits the very life of the plant of which it is the mature result. If its microscopic sporule-specks contain matter capable only of germination—as is the case with the Cryptogamia of Linnæus, the acotyledons of Jussieu, and the cellular plants of De Candolle—they attain only a cellular development; if the embryonic plantlet is capable of forming vessels, vascular tissue results, and we have monocotyledonous and endogenous growth; if the seed is charged with vitality capable of elaborating fibre, we have dicotyledonous and exogenous growth and fibrous products. And thus, in an unending round of reproduction, like originates like—new plants similar in kind to those which ripened the seed from which they spring "in endless round" appear. This fruit-bearing, *i.e. seeding*, is the supreme and crowning effort of plants to secure the reproduction of their kind.

Nature has instituted two methods of reproduction among plants. The first and simpler is that of germination, *i.e.* the endowment of a special small particle of matter—inclosed in a vesicle, and named variously, according to notions entertained of its nature and use, urticle, spore, sporule, or germ—with the power of taking upon itself an independent, individual existence and development similar to that which characterizes the productive parent plant. A germ is not matured by floral organs, and contains no embryo. Multiplication by germination is called *agamogenesis*. It consists in the production of a new individual plant directly from a structure—cell, bud, or branch—detached, either naturally or artificially, from a previously developed plant. The second and more complex plan is that of *seeding—i.e.* of producing within the floral organs of a parent plant seeds containing all the rudiments of an individual plant, very commonly also provided with a store of nutrient matter as a provision for the maintenance of the plantlet in the early stages of its development. A seed can germinate only from one point; a germ can from any point emit filamentous fibres, on some part or other of which the real plant appears, constitutes itself, and assumes the character of the parent from which it proceeded, and the filamentous tissues, being absorbed, disappear. This is the point at which Nature makes ready to renew the process of growth, and to complete the circle she began at the root, under the great law of reproduction which governs all animate things.

Seed formed by a perfect plant is developed as a result of fertilization, and is detached from the parent when ripe. It consists of two parts: (1) the general covering, which is called the spermoderm, consisting of an external membrane, the testa (shell) or episperm, and an internal lining or tegumen, the endopleura. The episperm or testa is cellular, and is often coloured. In the Circassian bean and crab's-eye bean they are of a bright red, and in cotton they are covered with hairs. The endopleura is cellular also. It is generally thin and transparent, and is often closely applied to the embryo. (2) The embryo or young plant, consisting of radicle or end of axis, plumule or young stem, and cotyledons or seed leaves. To induce the embryo to develop, there are required (1) a fitting soil, (2) a proper degree of temperature, (3) free access to air, (4) protection from the direct rays of light, and (5) a sufficiency of moisture. Given these and a healthy, mature organization, the new plant takes on its own *axis* or centre of growth, downward to the soil, upward to the air, and form, structure, and function become manifest.

The centre of the flower contains the apparatus in which the seed originates; and in the innermost core and centre of the seed lies the exquisitely sensitive rudimentary embryo, which is the finished and final product of the flower. The calyx, the ultimate extension and expansion of the cortical system of the plant, aids in the preparation and distribution of the fluids requisite in fecundation. The corolla matures those fluids, and converts them into those specific matters by which that important function is performed. The pistils, occupying the heart of the flower, contain in its carpel cases the ovary in which the ovules originate. The stamens by their pollen-powder fertilize the ovaries, and the fruit is the ripe pistil in which the ovules, perfected into seed, are contained.

In tracing the process of fertilization the main particulars requiring to be attended to are, (1) the external covering of the anther—that knob-like body which is the fertilizing organ of a flower; (2) the cellular matter with which it is filled; (3) the walls which form the lobes of it; (4) the cavities or cases formed within these walls; (5) the pollen secreted in these cases; and (6) the manner in which the pollen is shed.

(1) The external covering consists of a globular row of cells, forming a sort of outer skin, named *exothecium* (Gr. *exo*, outward; and *thekion*, little repository). The lower part which joins the filament (p. 624) is called the back, and the part opposite to it is the face. Stomata, *i.e.* minute holes or pores, and projecting points or prominences make their appearance on its surface.

(2) The interior of this little knob, box, or ball, in its incipient state, is occupied with cellular matter, the whole mass of which is different from the outer covering. Each cell of its tissue, when minutely examined, is found to have diffused through it spiral, annular, or reticulated fibres, which serve to define their outline. The anterior and posterior cells are, in respect of the different structures of its upper and under surfaces, analogous to the laminæ of the leaf. The function of these cells is to contribute mucilage for the nourishment of the seed.

(3) This cellular matter by and by begins to be pervaded by the filament; very generally a fleshy membrane, called the connective, is extended from the top of the filament for that purpose, and differs in structure from the spiral vessels which terminate the cellular fibres. The presence of this agent cleaves the anther into two or more bag-like masses or chambers, the face of which is expressed by a furrow or suture. These divisions are called septa, partitions, or lobes. The connective is not the cover of the lobes, but is merely the membrane that unites them. Occasionally it is of considerable size, as in *Bignonia manicata*, where it extends entirely across the lobes; but more frequently it encompasses only a small portion, as in *Mercurialis annua*. If an articulation exist at the point of junction with the filament, as in grasses, the anther is rendered slightly movable or versatile. When the base of the anther stands upright on the filament, it is *innate* or erect; but when the lobes lie on each side of the connective, as in Ranunculus, the anther is *adnate* or adherent. When the connective is horizontal and bears lobes at a distance from each other, it is *distractile* (Lat. *dis*, and *traho*, to draw), as in garden-sage. The connective is pointed in Acalypha, conical in the Brazilian balsam-bearing Humiriad, spurred in sweet-violet, and has a feathered prolongation in the common rose-bay.

(4) As the development of the seed approaches completion, a cavity is formed in the interior of each compartment of the anther. The wall which it arches with a row of fine cells—placed towards each other in contact or in wider degrees of proximity—is called the *endothecium* (Gr. *hendon*, inner). The cavity itself is a *loculus* or pouch; and the one or other of the two terms are used, in common practice, to characterize it. When one cavity only exists, the anther is called *monothecal* (Gr. *monos* and *theke*), or *unilocular* (Lat. *unus*, one; and *loculus*), as in bladder-nut. When there are two cavities, it is *bilocular* or *dithecal* (Lat. *bis* and *dis*, twice), as in

stock-gillyflower. When four cavities are present, either in apposition, as in the spurgewort (known as Poranthera), or in vertical relation, as in Avocada-pear, the name given is *quadrilocular* or *tetrathecal* (Lat. *quatuor*, and Gr. *tetros*, four). More numerous cavities occur in Patmaworts and mistletoe.

(5) The *loculi*, or pouches of the compartments of the anthers, are merely hollow cases filled with pollen cells. Within or from them the farina or pollen is produced that effects vegetable impregnation. The colour of the pollen is often yellow, but also red and blue, with their several modifications of shades, excepting green. It is yellow in Eschscholtzia, red in peach, and purple in poppy. To the unassisted eye pollen presents the appearance of fine dust; but under the microscope each grain is transformed into a hollow ball, in which floats an oily fluid in particles from the one-thirty-thousandth of an inch in diameter downwards, interspersed with elongated corpuscles somewhat larger, and a granular semifluid matter called the fovilla (Lat. *foveo*, I nourish). In the progress of development the grain becomes divided into four cells or parts, each forming a granule of pollen, and ultimately absorbing the parent cell, or resolving it into a surrounding viscous element. The granules either remain single, as in mistletoe, or adhere to each other in masses, then called pollinia, which include a definite or irregular number of granules. The pollinia vary in different plants, two being usual in *Orchis morio*, four in Cattleya, and eight in Lælia. In the *Acacia ringens*, *decipiens*, and *linearis*, eight, twelve, and sixteen respectively are united together. Each of these masses contains myriads of prolific atoms. Amici calculated 120,000 in a single stamen. Painstaking observers inform us that each stamen of a pæony produces 21,000 grains, and that a single head of dandelion supplies upwards of 240,000 in number.

The surface of the pollen is either (1) smooth, (2) depressed, or (3) raised in rounded pores. There is a single depression in Welsh onion or Cibroule, three in trailing bindweed, while in some other plants as many as twelve are to be met with. The rounded pores are also various; there is only one in cock's-foot grass, and, when more numerous, they are scattered over the surface, sometimes in a regular, and at others in an irregular manner. Spines, hairs, and crests often surround the pollen-grains with their projections.

The usual forms of pollen-grains are (1) ellipsoidal, as in marsh hibiscus; (2) trigonal, with convex sides, as in broad-leaved-tree primrose; (3) square cylindrical, as in common Virginia spiderwort; and (4) polyhedral, as in garden and wild succory. Spheroidal and oval forms, with attenuated extremities, are also frequent. As these forms offer a delightful exercise for microscopic observation, especially when a reflected light is employed, we subjoin the following select and useful list for the student's further practical examination:—

Anagallis, ...	Pimpernel.
Arbutus, ...	Strawberry-tree.
Campanula trachalium & nitida,	Bell flower.
Cineraria maritima, ...	Sea cineraria.
Circea luteiana, ...	Common enchanter's nightshade.
Coreopsis lanceolata, ...	Spear-leaved coreopsis.
Digitalis purpurea, ...	Purple foxglove.
Elymus sabulosus, ...	Lyme grass.
Fuchsia globosa and caccinea, .	Fuchsia.
Geranium sanguineum, . . .	Bloody crane's-bill.
Hieraclium sibiricum, . . .	Siberian cow-parsnip.
Lychnis flos cuculi, ...	Red meadow lychnis.
Malope trifida, ...	Three-lobed malopé.
Pancratium declinatum, . . .	Pancratium.
Salvia interrupta, ...	Sage.
Scirpas romanas, ...	Club rush.
Solanum dulce, ...	Nightshade.
Symphytum officinale, ...	Comfrey.
Viola tricolor, ...	Violet.

Pollen-grains, when minutely examined, are seen to be invested with two coverings; the external, called *extine* (Lat. *exto*, I stand outward), which gives form and colour to the grain, and the internal, or *intine* (Lat. *intus*, within), which is thin, transparent, and flexible. But between these envelopes some acute botanical anatomists profess to detect two others, known as *intextine* and *exintine*, formed by foldings of the outer and inner membranes. The formation of the inner coats takes place first, the others are due to a subsequent deposition in the parent cell.

(6) The discharge of the pollen is called *dehiscence*. This term includes, in a large sense, (1) the diffusion following on the bursting of the anther and the issue of the grains through the superficial outlets that are formed, (2) the internal propulsion employed to evacuate by them, and (3) the organic irritability and foreign agencies which contribute to the result as well.

The outlets to promote the escape of the pollen are made by clefts, lids, hinges, or pores.

(1) *Clefts* take effect along the face of the groove formed by the membranous connective which forms the suture. When the lobe is erect the dehiscence is longitudinal, as in *Byrsonima biscorniculata*. It is transverse in common ladies' mantle.

(2) A sort of blade, opening from a joint, forms a *lid*, which separates from the apex; and this dehiscence is called *circumscissile* (Lat. *circum*, around; and *scindo*, to cut), or *operculate* (Lat. *operculum*, a lid). The gamboge plant, passion flower, and gourd present instances.

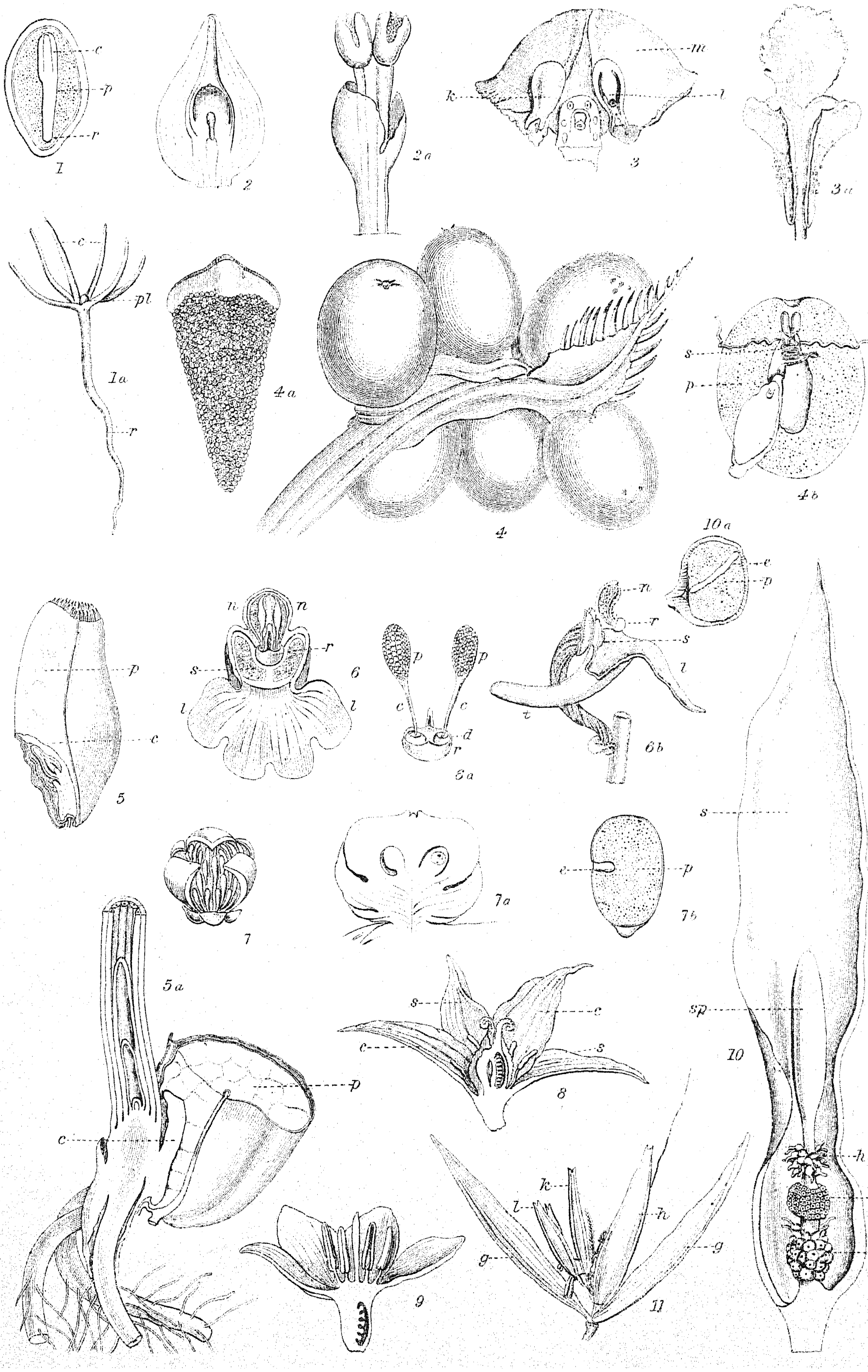
(3) *Hinges* of the anther are formed by a valve rolled up on the outside of a suture. In the barberry there is one, and in laurel two such valves, for each lobe of the anther.

(4) *Pores* are glandular holes placed on the base or apex of anthers, but sometimes on the sides, as in mistletoe. Each *loculus* opens by a single porous duct in the round-leaved winter-green, as *Pyrola rotundiflora*, by two in *Vaccinium uliginosum*, and in *Tetratheca juncea* by four uniting in a single passage at the top. Heath rhododendron and the potato supply other examples.

The spiral tissues of the wall-lining of the *loculi*, *i.e.* the endothecium, are left entire after absorption of the cells which surround them. At this point a striking proof of the perfect adaptation of organic matter to the end of its creation occurs. The absorbent powers of the pistil having imbibed the superfluous moisture of all the surrounding parts, the spiral vessels of the anther come into play as tiny springs (acquiring their power by combination), and, after contracting sideways, at length succeed in severing the walls of each lobe. These lobes burst and scatter their pollen at the exact time the stigma is prepared for its reception. Such elastic filaments are seen in the common nettle and pellitory. In marsh parnassia and rue the anther thus scatters its contents. The pollen sacs of kalmia spring out towards the pistil on the same principle, and similar phenomena are observed in Canadian dogwood, &c.

But besides this elasticity, which depends on the mechanism of the organs, there is a principle of chemical irritability also concerned in fertilization. The operation in this case results from the stimulation of contact. This will be obvious after consideration of the following instances:—When the recurved valves, covered over with pollen, have attained to ripeness on the common barberry, their pressure upon the base of the pistil has the effect of moving the stamens towards it, and causing their discharge. In Australian stylewort a common column projecting from the flower envelopes the stamens and pistil; and when the base of the former is brought into contact with the latter by the progress of growth, or from any other cause, whether permanent or temporary, the stamens jerk to the side with a suddenness that ruptures the lobes and scatters the pollen. Such apparatus and devices for insuring the fecundation of species are greatly diversified. Marsh parnassia, common rock-rose, and unequal-leaved ruellia exhibit staminal movements of a similar character.

The general position in which the anther opens lies so that the pollen emitted by the stamen may fall readily upon the pistillary organs. To this arrangement there are, however, many exceptions, and we find the organs occasionally so placed that it is impossible to account for their united action without the agency of wind, water, insects, &c. In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the hazel and willow the organs of reproduction stand separate in different flowers; fertilization, therefore, always precedes production of the leaf, and the diffusion of the pollen from this cause meets with no interception. The pollen of firs is during spring strewed upon the ground in enormous quantities, as a provision for its application notwithstanding the presence of leaves, and its yellow showers are even sometimes carried to great distances. In aquatic plants, such as African Hydrocharad, and in two-stamined Vallisneria the female plant is borne on a spiral stem, which accommodates itself to the depth of the water; but the male plant, which grows near, becomes detached at the period of flowering from the bottom to which it was bound, floats to the surface, and discharges its pollen into the expanded partner-flower before it is caught by the rippling wave. The female plants then contract their spiral stems, sink into the ooze, and ripen their seed under water.

Bees, aphides, spiders, and flies greatly aid in the process of fertilization by their resorting to the nourishing sweets secreted within the flower. In several species of birthwort the anthers are placed below the stigma, and the whole is shut up within the tube of the calyx, the interior of which is furnished with deflexed hairs; insects, therefore, entering in search of food, apply the pollen in their efforts to escape. A small beetle, a native of the wilds of Kamtchatka, by its search for food facilitates the abundant reproductiveness of the *Lilium kamtchatkense*, the bulbs of which are roasted and eaten in Siberia and form a large part of the winter food of the inhabitants of Greenland. The breeze, too, carries the pollen of the date-tree across the desert, and the wave wafts the prolific fruit of the palm to distant shores. The roving bee, while supplying the wants of its young, is necessarily securing the fertilization of seed.

The student's attention must next be directed to (1) the specific structure of the pistil, which is the centre of a complete flower. It constitutes the inner whorl, and is the female organ of the plant. When mature it is converted into fruit, and contains the seed. (2) The theory of fertilization or fecundation.

1. The pistil is composed of modified leaves called *carpels*. When it consists of but one carpel it is *simple*, and when of more than one united it is *compound*. The rounded top of the pistil (see p. 625) is called the *stigma;* the stalk, if any, upon which it is raised, the *style;* and the swollen part at the bottom, containing the cells which become seeds, the *ovary*.

The *stigma* is a loose and spongy expansion of the cellular tissue of the style, dotted over with minute little swellings, termed papillæ. The process is smooth in the water lily, but the papillæ are developed into hairs in the small nettle. The stigma assumes in grasses the form of a hairy tuft or brush. As these papillæ become more minute, and at last disappear in the ovary, the stigma is an absorbent device. It secretes a viscous fluid, in some cases acid, but more generally saccharine, for combining with the pollen at the period of fertilization.

The *style* is formed by an extension of the midrib of the carpel, with the other tissues enveloped in it, and is hence both of a cellular and vascular nature. It is traversed lengthwise by a canal, the inner surface of which is coated with a row of projecting cells called the conducting tissue, on account of its function in transmitting the pollen downwards. Its general position is *apicilar* (Lat. *apex*, top), *i.e.* on the summit of the ovary. The organic apex of the ovary is not always the apparent apex; hence the style may be found, as in cocoa-plum, to be *basilar*, *i.e.* arising from the base. When prolonged continuously from the torus (as in Ochna) it is called *gynobase*. The styles may be either separate or united. When single (as in angular-leaved physic nut) it may be bifurcate or forked, and where two or more styles exist each may allow of a similar division. In form the style is usually cylindrical or triangular. It is petaloid in Indian reed. In vetch and throatwort it is furnished with hairs in various forms, which assist in collecting and scattering the pollen.

The lower portion of the carpel is the *ovary*, or organ which secretes ovules, and is usually called *germen* by the Linnæan school of botanists. Its cellular texture, ramified with spiral and other vascular bundles, is consolidated into a spherical or curved form, and incased in an epidermis which is either smooth or hairy. The limb of the carpel leaf is either closely or more loosely united; and the fold is marked by dorsal or ventral sutures, expressed by projected or grooved lines along the surface. It is either free or fixed to the calyx or other surrounding parts; and is said to be superior or inferior, according to the complete (as in melon) or partial (as in saxifrage) adherence of the one with the other. Along the united edges of the carpels a thickening takes place, and a projection or process, called a *placenta*, is formed, to which the ovules are attached. When the carpels fold inwards, so that the placentæ proceed to the centre and unite, they form a *central* or *axile placenta* bearing the ovules, which are then turned outwards, as in the iris. When the carpels are folded inwards, so that the placentæ are only projections from the walls of the ovary, these are called *parietal placenta*, as in the poppy. The united edges of the carpels when they proceed to the centre divide the ovary into cells, and each division is then called a *septum* or a *dissepiment*. When the dissepiments formed by the inwardly folded carpels are obliterated the ovules are borne on a column standing free in the centre of the ovary, and called a *free central placenta*, as in the pink and primrose. When the ovary is divided into cells by means of the dissepiments it is described as *bilocular*, *trilocular*, or *multilocular*, according to the number of the cells.

Attached to the placenta is the *ovule*—a sort of seed-bud. It enlarges itself from a small cellular mass into an ovoid form. It stands on a base called *chalaza*, which is a denser membrane, sometimes tinted, compounded of cells and vessels, and traversed by a tissue from the placenta. The relations of the ovule to its contiguous parts determine its position. The ovules are called *definite* when sufficiently uniform to be counted in the ovary, but when their position exhibits such a variety as not easily to admit of enumeration *indefinite*. Each ovule itself consists of the nucleus, integuments, and embryo sac. The ovule contains the rudiments of a future vegetable, which is derivatively transformed from its various parts by slow but successive evolution. Every fibre in it contributes its share towards the production of that specific form of development which constitutes and results in a perfect plant of the selfsame kind. The outlines inherent to the cell, in short, are merely filled up, as it were, from a first sketch, by the several processes which form its after physiology.

2. We must now look at the change which takes place on the pistil when the pollen reaches and fructifies it.

The application of plant-juice to a particle of pollen occasions a great change of the form it exhibits in a dry state. The effect may be easily shown, in the way of experiment, by immersing a grain in a vessel of water. Exposure to that element is attended in general with a rupture of the extine, in the first instance; and the intine, though resisting more from its greater distensibility, ultimately gives way, either through the first rupture or the folds or pores of the outer surface. The immediate consequence is the escape of the *fovilla*, *i.e.* the vegetating contents of the cells. This result indicates what occurs after fertilization or fecundation commences.

When the process of fertilization takes place the mature pollen is discharged from the anthers upon the stigma, to which it is attached by means of the viscid secretion already alluded to. Whilst in this position the pollen grains develop small tubular processes, which pass through the loose cellular structure of the stigma down the style to the ovary. These tubes then penetrate the ovules, and discharge into them the contents of the pollen grains, and thus a union is effected between the fovilla or fertilizing principle of the pollen, and the semifluid contents of the ovule. After this process the style commonly falls away, and the ovary ripens into fruit, inclosing fertile seeds.

As it is not always easy to get exactly what is required to explain terms precisely to the sight, and even when had to arrange and present them so that what is seen may aid in the understanding of what is heard or read, we present to the student's eye a Plate (IX.), in which he will find several views of portions of the parts of fructification so arranged as to bring out the meaning of the terms used, and to show their

appearance and relation. We direct the attention of the reader first to those figures which refer to monocotyledonous plants. We, therefore, refer to the section of a grain of wheat (fig. 5), where *c* indicates the single cotyledon of this most important and very extensive order of plants (for the grain of wheat may be taken as the type-form of the most valuable of the food and pasture plants), and *p* shows the albumen treasured up for the nourishment of the tender embryonic seedlet. The process of germination—*i.e.* of exchanging the condition of an embryo for that of a young plant—is exhibited in fig. 5*a*. In this *c* again shows the cotyledon, and *p* the pabulum of the embryo; the root—with its adventitious thread-like filaments—is seen in its downward progress, and the plumule or gemmule in its upward growth. Of the Microspermeæ, the *Orchis mascula* presents a good type. The anther, consisting of two cells, is seen at *n* in fig. 6; *r* is the rostellum, a thickened portion of the stigma—from which a peculiar gland separates—that holds the pollen-masses together; *s* is the stigma; *l* the labellum, or lower lip of the labiate corolla (which in the orchis so frequently assumes a grotesque appearance); *t* on fig. 6*b* is the nectary; *p* on fig. 6*a* the pollen masses; *c* the caudicle, a thin, semi-transparent, elastic process of the pollinium, by which the pollen is brought into contact with the stigmatic gland (mentioned above); and *d* the viscid disc of the pollinium. The male flower of the Gamuto palm of the Indian Archipelago is shown in fig. 7; fig. 7*a* presents a section of the female flower; and fig. 7*b* gives a vertical section of one of the three seeds taken from its yellowish-brown berry; the embryo being marked at *e*, and the albuminous pabulum at *p*. This supplies a fair specimen of the Calycinæ. At fig. 8, the outer leaves of the perianth of Trillium, one of that singular order of poisonous endogens which conforms to the characteristics of the Liliaceæ in all other main points except that they have their anthers turned (as is seen in the figure) towards the sepals and petals, and their styles or carpels separate, or at least separable; *s* indicates the sepalatous outer leaves, and *p* the petalous inner leaves of the campanulate perianth; the ovary is seen in section. Of epigynous flower-structures, in which the filaments of the stamens grow upon and rise up from the summit of the ovary, the specimen chosen (fig. 9) is *Leucojum vernum*. The cuckoo-pint or wake-robin (*arum*, fig. 10) exhibits very clearly the arrangements by which the fertilization of plants by insects is accomplished. The large encircling greenish-yellow bract or spathe (*s*) is seen narrowing round the inflorescence. On the violet or brownish-red central pillar or spadix (*sp*) there grow, pointing downwards, hairy filaments; at *h* rudimentary stamens are shown; *n* indicates the male flowers, and *o* the ovary with its single-carpelled female flowers. It would seem that, by the mere dropping of the pollen from *n* to *o*, the whole purpose of fertilization would be at once and easily accomplished. In the arum, the upper surface of the stigma becomes moist and sticky whenever the ovules are ready for fertilization. This is in order to catch the pollen as it touches them, but it soon dries up. Arum anthers do not usually shed their pollen on the same plant till the stigma has dried up. Thus no flowers can be ripened by self-fertilization upon the plant. Insects, however, in search of food, passing down the gorge of the spathe, reach the nectary (*n*). They are then prevented, by the ciliary apparatus, from returning till their bodies have been well dusted with pollen. After the pollen is shed, the entrapping hairs wither, off flies the liberated insect, bearing with it the fertilizing pollen of the one plant to the stigmata of another, and so on. The embryo of the arum is shown, fig. 10*a*, in a section of its seed at *e*, and its albuminous pabulum at *p*. At fig. 11, a spikelet of oats exhibits at *g g* the outer ensheathing glume or imbricated scaly bract (green or brown), which takes the place of calyx and corolla in the grasses. At *h* and *k* are the flowering glume and paleæ or interior bract, while *l* shows another "flower of the grass" in bud.

Passing from the illustration of those parts of plants involved in the consideration of the seed and fertilization of monocotyledons, we proceed to direct attention to the parts of the Gymnospermeæ—*i.e.* those plants whose ovules or young seed (*spermata*) are placed in an open (*gymnos*) receptacle, as distinguished from the Angiospermeæ, which have their seed contained in some sort of vessels (*angios*), of which many examples were given on Plate VIII. The pollen-grain of gymnosperms consists of two cells, and the endosperm (*endon*, internal) or albumen of the seed is formed prior to and not after fertilization. The seed of a pine, with its cotyledons, is shown on Plate IX., fig. 1, at *e*; the radicle is indicated by *r*, and the albumen by *p*, and at fig. 1*a* the embryo is shown; *c* indicates cotyledons, *pl* the plumule, and *r* the radicle. The seeds of *Gnetum gnemon* are, when boiled, fried, or roasted, used as an article of food in Amboyna. Of the utricular or bladder-like female flower we present a vertical section at fig. 2, and of the anther-headed male flower at fig. 2*a*. The long cylindrical cones of the Norway spruce (*Abies excelsa*) hang pendulous from the branchlets, and exhibit denticulate scales, having one or many ovules on the scales of the female flower. A scale from a female cone is represented at fig. 3, in which *k* indicates the ovule, and *l* shows, in section, the nucleus. A male flower is presented in fig. 3*a*. Sago is made in the Moluccas from the cellular substance of the *Cycas circinalis*, of which we show a spadix with ripe fruit (fig. 4). An anther-bearing scale (as seen from below) appears at fig. 4*a* on the left, and at fig. 4*b* on the right a vertical section of the albumen, with the embryo, is exhibited. The embryo is undivided, owing to the cohesion of the cotyledons. The filaments of the undeveloped embryos are drawn out on each side, and the radicle is superior.

While reading these details with Plate IX. before him, and with Plate VIII. ready also for reference, the student will soon learn to comprehend with clearness the definitions supplied in Chapter VII. (pp. 624–626), and to understand the nature of the process of fertilization as just explained. To do these things, however, he must constantly apply what he has read to the interpretation of what he has seen, and use what is shown as an aid to the interpretation of what has been read—"applying *this* to *that* and *so* to *so*."

THE GERMAN LANGUAGE.—CHAPTER X.

NUMERALS: DEFINITE AND INDEFINITE, CARDINAL, ORDINAL, ETC.—ILLUSTRATIONS AND EXERCISES.

The study of German is not only highly useful as an acquisition which brings us into relation with a nation of thinkers, but also because its advantages in commercial circles are growing wider and more known. In consideration of the great importance of a proper knowledge of numerical expression in the use of a language, now greatly in demand in business and the details of trade transactions, we think it will conduce much to the good of the student to devote a considerably larger space than is usual in German grammars to the explanation of the different, and often extremely difficult, class of words bearing the designation of *numerals*.

Numerals are, in a grammatical sense, the words by which numbers and quantities are expressed, indicated, or suggested. They are the terms in which arithmetic and commerce set their details before the mind. Some of the distinctions of numbers are plain, easily known, and readily employed and applied; but many of them are subtle and intricate. Nor is this to be wondered at. The use of numerals, though probably among the earliest necessities of man, must soon have passed beyond being a mere embodiment of some concrete and experienced sense of number and quantity, and taken the form of abstract expressions. Number strips away from the things seen and known all those properties and qualities by which they impress the senses, and realizes them in one single simple relation—that of singularness, fewness, or manyness. By a sort of ready shorthand, numeration took an early step in simplifying the signs of thought, and began that prime method of symbolization which has resulted in the figures of arithmetic and the letters to which a numerical value is assigned in algebra. The notions of increase and diminution, of variableness in number and in dimensions, required that some unity, in relation to which quantity and number could be indicated, should be determined on. Numerals are the means by which these relations are expressed. Sometimes the notion of number may be brought before the mind as a *fact*, and thus the word expressing it is (or is equivalent

to) a noun. In most cases, however, numerical relations are thought of as connected with, and in a certain sense qualities of things, and hence they are most frequently adjectives. Our ideas of number may be, and often are, precise and exact, in which case the adjectives expressing them are called *definite*. They are, however, not unfrequently ill-defined, vague, inexact, or incapable of being known or expressed in a distinct and determinate manner. An adjective expressive of this hazy sort of idea of number is called *indefinite*.

Numerals denoting a whole number—one or more—are clearly and distinctly marked. The formation and arrangement of a system of names of numbers referring to entire quantities or aggregates is perhaps one of the earliest processes of numeration. On the accomplishment of this special result all further development of numerical indications depends, and the names of such numbers are therefore regarded as *cardinal*. After the fact of numerical aggregation has been registered in a nomenclature, the order in which the elements of any quantity gathered together into a comprehensive whole, stand towards each other, requires next to be suggestively expressed. This leads to the use of certain words (*i.e.* signs), denoting order of place, relation, &c., and gives rise to *ordinal* numbers. But things are not always spoken of as wholes. They frequently require to be thought of as separated, divided, increased, lessened, &c., and so we have need of words denoting fractional parts, combination, &c., and to the fulfilment of this function other numeral adjectives are assigned. By these manifold means, language has accumulated a series of words expressive of the several conditions and changes of condition which things assume to the mind in reference to number; and grammar, as the exponent of the laws and customs of speech, has found few of its tasks so bewildering as the settlement of the questions which arise regarding the proper use of numerals.

In the study of any language it is interesting to know how they managed so requisite a piece of intellectual and social life as that of dealing with numbers. This subject, however, attains an intense importance when it is engaged in as a part of the learning of a living language, of a knowledge of the actual usages of which it is of vital moment we should become possessed, if we would acquit ourselves well in the everyday employment of that special speech in the common business of life. It is easy to see—if we think for a second on the peculiar power which notions of number have over human life, the frequency with which such notions enter into our minds, demanding our attention in the concerns of every hour, and the special need for familiarity with numbers, their properties, processes, signs, and relations in commerce and business—that one of the most essential requirements of anyone who would employ a language is a correct, adequate, and idiomatic knowledge of the words dealing with quantity, number, price, &c., in merchandise, social life, trade, and labour. It is almost as clear, on brief reflection, that few words are more likely to be employed in special idiomatic forms than those which by their familiarity require and acquire a ready recurrence in almost every transaction of life. Now all such phrases, depending as they do very largely on the habitual usages of market and farm, counter and desk, workshop and factory, trade and commerce, bookkeeping and correspondence, are clear, intelligible, and easily dealt with by those whose mental associations and actual experiences are quite familiar with them as matters of incessant thought and frequent employment. But to a learner, to whom words, phrases, habits of life, dealings of men with men, are all unfamiliar, they must present more than ordinary difficulty. By writers of books on German grammar these very familiar things seem as if they required no explanation, and very seldom get much. Feeling that this is a mistake in dealing with such a language as German we have resolved to bestow great care on this department, knowing its indispensable necessity to all who would use the language for commercial purposes or in the ordinary requirements of social life. We proceed, therefore, to deal now with this more important kind of words—the numerals.

Numerals express the relation of number and quantity. Those which express the relation of number imply either (1) a definite or (2) an indefinite number; as one, two, three (definite); many, all, none (indefinite). Those which express the relation of quantity imply only an indefinite quantity. Numerals are therefore either definite or indefinite. In German numerals are treated as adjectives.

CARDINAL NUMERALS.

Definite numerals form several classes. The first class (from which all the other classes are derived) comprehends the *cardinal* numbers (Lat. *cardo*, a hinge), so called because they are those upon which the others hinge.

These numbers are used as in English, with this difference, that in numbers of two figures the single number is always named before the decimal number; as drei und zwanzig, three and twenty.

THE CARDINAL NUMBERS ARE—

1	Ein, eine, ein, or Einer, eine, eines.*	11	elf or eilf.
2	zwei.	12	zwölf.
3	drei.	13	dreizehn.
4	vier.	14	vierzehn.
5	fünf.	15	fünfzehn.
6	sechs.	16	sechzehn.
7	sieben.	17	siebenzehn or siebzehn
8	acht.	18	achtzehn.
9	neun.	19	neunzehn.
10	zehn.	20	zwanzig.

Vier, Fünf, and Sechs have a plural, and take the termination en in the dative when employed without any substantive; as Affen gehen oft auf Vieren, monkeys often walk on four legs; in einem Zimmer standen drei Tische, in dem andern fünfe, there were in one room three tables, and in the other five.

Zwei and drei have a genitive, zweier and dreier, which is used only when the genitive is not expressed in a preceding article or pronoun; as der Vater dreier Söhne, the father of three sons; but der Vater dieser drei Knaben, the father of these three boys. The dative also of the cardinal numbers is used, but only when they are not followed by a noun; as mit sechsen fahren, to drive with six (horses); mit zwanzigen sich messen, to measure one's strength against twenty (opponents).

Up to one hundred the small number always precedes the large one.

21	ein und zwanzig.	36	sechs und dreißig.
22	zwei und zwanzig.	37	sieben und dreißig.
23	drei und zwanzig.	38	acht und dreißig.
24	vier und zwanzig.	39	neun und dreißig.
25	fünf und zwanzig.	40	vierzig.
26	sechs und zwanzig.	50	fünfzig.
27	sieben und zwanzig.	60	sechzig.
28	acht und zwanzig.	70	siebenzig.
29	neun und zwanzig.	80	achtzig.
30	dreißig.	90	neunzig.
31	ein und dreißig.	100	hundert.
32	zwei und dreißig.	101	hundert und eins.
33	drei und dreißig.	200	zweihundert.
34	vier und dreißig.	1000	tausend.
35	fünf und dreißig.	1001	tausend und eins.

Zehntausend, ten thousand; hunderttausend, a hundred thousand; eine Million, a million; zehn Million, ten millions; hundert Millionen, a hundred millions; zehntausend Millionen, ten thousand millions; hunderttausend Millionen, a hundred thousand millions.

All numbers above 100 are placed exactly as in English, but note how the number before hundert is joined to it (*e.g.* zweihundert).

1800 achtzehnhundert, or ein tausend achthundert.
1815 achtzehnhundert und fünfzehn, or ein tausend acht=hundert und fünfzehn.
1889 ein tausend achthundert (or achtzehnhundert) neun und achtzig.

* Eins is the form always used in counting; but if a noun follows the numeral, ein is declined like the definite article, throughout all the three genders.

2708 zwei tausend siebenhundert und acht.
15,927 fünfzehn tausend neunhundert sieben und zwanzig.
136,748 hundert (und) sechs und dreißig tausend siebenhundert (und) acht und vierzig.

Hundert and tausend are not declined when preceding a noun as numerals; as mit tausend Grüßen, with a thousand compliments. In such cases as das hundert, die hunderte, das tausend, die tausende, and in compounds like das Jahrhundert, the century, das Jahrtausend, the millennium, they are to be treated as substantives of the neuter gender. Million is a substantive of the feminine gender.

EXERCISE.

Insert in the following sentences the numerals instead of the figures given, and commit to memory:—

Eine Woche hat 7 Tage, ein Tag hat 24 Stunden. Ein fleißiger Mann hat des Tages 12 Arbeitsstunden. Die Woche hat 168 Stunden, denn 7 mal 24 ist 168. Unter diesen sind für einen fleißigen Mann 72 Arbeitsstunden und 96 Ruhestunden. Wißt ihr, wie das gerechnet ist?

Das Jahr hat 12 Monate, und diese haben zusammen 365 Tage. Einige Monate haben 30, einige 31 Tage, der Februar aber hat nur 28. Wenn aber ein Schaltjahr ist, so bekommt der Februar 29. Dann hat das Jahr 366 Tage.

Das Jahr hat 52 Wochen. Im Frühling und im Herbst wahrt der Tag 12 Stunden und die Nacht 12 Stunden. Im Sommer wahrt der Tag 16 Stunden und die Nacht nur 8; im Winter aber ist 8 Stunden Tag und 16 Stunden Nacht.

A week has seven days, a day has twenty-four hours. A diligent man has twelve working hours in the day. The week has 168 hours, because seven times twenty-four is 168. Within these there are for a diligent man seventy-two working hours and ninety-six hours of rest. Do you know how that is reckoned?

The year has twelve months, and these have, taken together, 365 days. Some months have thirty, some thirty-one days, but February has only twenty-eight. When, however, a leap year is, then February gets twenty-nine. Then the year has 366 days.

The year has fifty-two weeks. In spring and in autumn the day lasts twelve hours and the night twelve hours. In summer the day lasts sixteen hours and the night only eight. In winter, however, there is eight hours day and sixteen hours night.

ORDINAL NUMERALS.

The second class of numerals are called *ordinals* (Lat. *ordo*, order). They are formed from the cardinals, and are made (1) up to twenty by adding t (or rather te) to the cardinal number. They are generally used with the definite article; as der zweite, the second; der vierte; the fourth. (2) Zwanzig, twenty, and all the following numbers add ste; as das zwanzigste Kapitel, or zwanzigstes Kapitel, twentieth chapter; viertes Jahr, fourth year; dreißigster Abschnitt, thirtieth paragraph. Two, however, are irregular, viz. der erste, the first, instead of der einte; and der dritte, the third, instead of der dreite; der achte omits one t. From these two the following seven classes are formed:—(1) Partitives, (2) distinctives, (3) dimidiatives, (4) multiplicatives, (5) variatives, (6) fractionals, (7) reiteratives.

In compound ordinals the last number only takes the ending; as der ein und zwanzigste, the one and twentieth. They are easily learnt by heart, because they are all very much like the English numbers, and keep closely to the form of the cardinals if the addition is properly made. Ordinals may be considered as a kind of superlative.

THE ORDINAL NUMBERS ARE—

der erste, the first.
der zweite, the second.
der dritte, the third.
der vierte, the fourth.
der fünfte, the fifth.
der sechste, the sixth.
der siebente, the seventh.
der achte, the eighth.
der neunte, the ninth.
der zehnte, the tenth.
der elfte, eilfte, the eleventh.
der zwölfte, the twelfth.
der dreizehnte, the thirteenth.
der vierzehnte, the fourteenth.
der funfzehnte, the fifteenth.
der sechzehnte, the sixteenth.
der siebenzehnte, the seventeenth.
der achtzehnte, the eighteenth.
der neunzehnte, the nineteenth.
der zwanzigste, the twentieth.
der ein und zwanzigste, the twenty-first.
der zwei und zwanzigste, the twenty-second.
der drei und zwanzigste, the twenty-third.
der vier und zwanzigste, the twenty-fourth.
der fünf und zwanzigste, the twenty-fifth.
der sechs und zwanzigste, the twenty-sixth.
der sieben und zwanzigste, the twenty-seventh.
der acht und zwanzigste, the twenty-eighth.
der neun und zwanzigste, the twenty-ninth.
der dreißigste, the thirtieth.
der ein und dreißigste, the thirty-first.
der zwei und dreißigste, the thirty-second.
der vierzigste, the fortieth.
der ein und vierzigste, the forty-first.
der zwei und vierzigste, the forty-second.
der fünfzigste, the fiftieth.
der sechzigste, the sixtieth.
der siebenzigste, the seventieth.
der achtzigste, the eightieth.
der neunzigste, the ninetieth.
der ein und neunzigste, the ninety-first.
der hundertste, the hundredth.
der tausendste, the thousandth.
der tausend und erste, the one thousand and first.
der zweitausend und dritte, the two thousand and third.
der sechstausend und siebente, the six thousand and seventh.
der neuntausendste, the nine thousandth.
der zehntausendste, the ten thousandth.
der hunderttausendste, the one hundred thousandth.

The Germans also use the following diminishing ordinal forms, viz.—

der letzte,	the last.
der vorletzte,	the last but one.
der vorvorletzte,	the last but two.
der drittletzte,	the last but three.

The ordinal numbers are used in German, (1) for the dates of months; as den ersten Januar, the first of January; den zweiten Marz, the second of March; den zwölften August, the twelfth of August; and (2) to show the succession of the princes who have reigned; as Franz I. (der erste), Francis the first; Franz II. (der zweite), Francis the second; Heinrich III. (der dritte), Henry the third; Heinrich IV. (der vierte) Henry the fourth. The ordinal numbers are preceded by the definite article; as der, die, das erste, the first; der, die, das zweite, the second. When ordinal numbers are used in conjunction with the proper names of reigning princes they are placed after the names, and are in this case written with a capital initial; as Karl der Fünfte war Kaiser in Deutschland zur Zeit der Reformation, Charles V. was Emperor of Germany in the time of the Reformation.

Here follow a few examples of their use (translated):—Erster Zeitraum, dritte Abtheilung, zweites Jahr, first period, third division, second year; der vierte Bote, die fünfte Vorstellung, und das zehnte Urtheil, the fourth messenger, the fifth representation, and the tenth sentence; Mein eilfter Monat und deine zwölfte Reise, my eleventh month and thy twelfth journey; Sein zwanzigstes Buch und ihr sechzigstes Capitel, his twentieth book and their sixtieth chapter; die drei tausend sieben hundert und fünf und vierzigste Zahl, the 3745th number.

The student will have to notice that in compound numbers he gives only the last word the termination of an ordinal, and that the units are put before the tens; say—not der zwanzig zweite, but—der zwei und zwanzigste.

It had better be mentioned here that when the date of the month is indicated by an ordinal number it is always employed adjectively, and consequently not with von, of, as in English; as Ich bin am fünfzehnten März geboren, I was born on the fifteenth (of) March; der fünfte November, the fifth (of) November.

Notice here, at the same time, that the ordinals, when written with a cipher, must be indicated by a full stop; as Mein Vater starb in seinem 71. Jahre, my father died in his seventy-first year.

When *of* is to be expressed before any numeral beyond three, as the declinable ending of the genitive ceases there, it must be rendered by von. But all the numerals admit the

termination of the dative, which must be made use of, if that case is not marked by any substantive; as die Gegenwart von vier Richtern, the presence of four judges.

When cardinal and ordinal numerals are joined to nouns they are either followed by the genitive or by the prepositions von or unter; as zwei meiner besten Freunde (or zwei von meinen besten Freunden) sind todt, two of my best friends are dead.

When the exact number expressed by the cardinals cannot be stated, the following words are used:—bis and oder, etwa, ungefähr, einige (etliche), beinahe, kaum, fast, bei, gegen, an die, &c.; as sechs bis sieben Jahre alt, six or seven years old; sieben oder acht Fuß lang, seven or eight feet long; etwa or ungefähr neun Thaler werth, worth about nine dollars.

There are no words in German to express the meaning of *either*, *neither* (*i.e.* one of two, not one of two): the former is rendered by einer von beiden, the latter by keiner von beiden. There is no German word for *any: anybody* is expressed by Jedermann; *anything* by alles; *anywhere* (in every place), by uberall; *anyone* (someone), by irgend jemand; *anywhere* (in some place), by irgendwo; *at any time* (at some time), by zu irgend einer Zeit.

(1) The name *partitives* is given by German grammarians to a class of neuter substantives answering to the question, What *part* of? These are formed by affixing to the cardinals the suffix tel (contracted from the word Theil, a part), and taking the form stel, from twenty upwards; as

die Hälfte, ...	half ($\frac{1}{2}$).
das Drittel, ... der dritte Theil, ...	the third part ($\frac{1}{3}$).
das Viertel, ... der vierte Theil, ...	the fourth part ($\frac{1}{4}$).
das Fünftel, ... der fünfte Theil, ...	the fifth part ($\frac{1}{5}$).
ein Viertel, ...	a fourth part ($\frac{1}{4}$).
zwei Drittel, ...	two-thirds ($\frac{2}{3}$).
vier Fünftel, ...	four-fifths ($\frac{4}{5}$).
fünf Sechstel, ...	five-sixths ($\frac{5}{6}$).
sieben Achtel, ...	seven-eighths ($\frac{7}{8}$).
neun Zehntel, ...	nine-tenths ($\frac{9}{10}$).
ein Zwanzigstel, ...	a twentieth ($\frac{1}{20}$).
ein Dreißigstel, ...	a thirtieth ($\frac{1}{30}$).
ein Vierzigstel, ...	a fortieth ($\frac{1}{40}$).
&c.	&c.

Ein Halb (or eine Hälfte), a half; ein Drittel, a third, are used instead of ein Zweitel, ein Dreitel. Halb is also used adjectively; as Ich habe einen halben Sovereign verloren, I have lost a half sovereign.

Ein Ganzes (whole) hat zwei Halbe, drei Drittel, vier Viertel, acht Achtel, hundert Hundertstel, &c.

(2) *Distinctives* are formed by adding ens to the ordinals; as erstens, firstly; zweitens, secondly; zehntens, in the tenth place, &c.

(3) Another kind of *dimidiative* numerals are formed with halb; as

anderthalb	(two	less a half), ...	$1\frac{1}{2}$.
drittehalb	(three	"), ...	$2\frac{1}{2}$.
viertehalb	(four	"), ...	$3\frac{1}{2}$.
fünftehalb	(five	"), ...	$4\frac{1}{2}$.
sechstehalb	(six	"), ...	$5\frac{1}{2}$.
siebentehalb	(seven	"), ...	$6\frac{1}{2}$.
achtehalb	(eight	"), ...	$7\frac{1}{2}$.
neuntehalb	(nine	"), ...	$8\frac{1}{2}$.
zehntehalb	(ten	"), ...	$9\frac{1}{2}$.
zwölftehalb	(twelve	"), ...	$11\frac{1}{2}$.

EXAMPLES.—Ich habe meine Eltern in anderthalb Jahren nicht gesehen, I have not seen my elder brother for a year and a half; drittehalb Jahre, two years and a half; fünftehalb Sovereign, four sovereigns and a half; zeilftehalb Ellen, ten yards and a half; ein und zwanzigstehalb Meilen, twenty miles and a half; ein und dreißigstehalb Stunden, thirty hours and a half; anderthalb Fuß, a foot and a half. It is also quite correct to say zwei und ein halber fuß for $2\frac{1}{2}$ feet, but note that in such a form the Germans use *foot* in the singular.

(4) *Multiplicatives* are formed by adding fach or fältig, fold; as einfach, simple; zweifach, twofold; zehnfach, zehnfältig, tenfold; hundertfältig, tausendfältig, &c. Instead of zweifach one may also say doppelt, double.

(5) *Variatives* are formed by adding erlei to the cardinals; as einerlei, of one kind; zweierlei, of two kinds; dreierlei, of three kinds; viererlei, of four kinds; zehnerlei, of ten kinds; hunderterlei, of one hundred kinds, &c. Also mancherlei, of many kinds; verschiedenerlei, of different kinds. They are not declined.

Note.—Es ist mir einerlei, it is the same to me.

The following words are formed in the same way—viz. by the strong genitive declension preceding the old German word lei, kind or sort:—Keinerlei, not of any kind; as Dabei ist keinerlei Gefahr, There is no danger of any kind connected with it. Beiderlei, of both kinds; as Personen von beiderlei Geschlecht, Persons of both sexes. Mancherlei, of various kinds; as Es gab da Mancherlei zu kaufen, There were things of various kinds given them. Vielerlei, of many kinds; as Er hatte mir vielerlei zu sagen, He had things of many kinds to tell me. Allerlei, of all kinds; as Er spricht allerlei Unsinn, He speaks all sorts of nonsense.

Einpfündig, of one pound; zweipfündig, of two pounds; dreipfündig, of three pounds; vierpfündig, of four pounds; dreieckig, triangular; viereckig, quadrangular, square; fünfeckig, five-angled; sechseckig, six-angled.

(6) *Fractionals* are employed as the denominators of fractions, the numerator being expressed by a cardinal number; as

$\frac{1}{2}$ ein Halb.	$\frac{7}{20}$ sieben Zwanzigstel.
$\frac{2}{3}$ zwei Drittel.	$\frac{9}{42}$ neun Zweiundvierzigstel.
$\frac{3}{4}$ drei Viertel.	$\frac{13}{60}$ dreizehn Sechzigstel.
$6\frac{5}{8}$ sechs (und) fünf Achtel.	$50\frac{3}{11}$ fünfzig (und) drei Elftel.

(7) *Reiteratives* are formed by adding mal, time or times, to the cardinals; as einmal, once; zweimal, twice; dreimal, three times; viermal, four times; zehnmal, ten times; fünfzigmal, fifty times; hundertmal, one hundred times; hundert und viermal, one hundred and four times, &c.

From these reiterative numerals are derived the adverbial numerals einmalig, from einmal, one time, only once; as Ein einmaliger Versuch beweist Nichts, A trial made only once proves nothing; zweimalig, from zweimal, twice; dreimalig, from dreimal, thrice; mehrmalig, several times repeated, from mehrmals, several times; vielmalig, many times repeated, &c.

Mal is used as a noun when preceded by a demonstrative pronoun, as dieses Mal, this time; or an ordinal number, as das letzte Mal, the last time; das dritte Mal, the third time; zum dritte Male, for the third time; zum letzten Mal, for the last time, &c.

This mal is employed in multiplication; as sechsmal acht ist acht und vierzig, six times eight is forty-eight. The multiplication table is called in German das Einmaleins, *i.e.* "the one times one." The student who wishes to master the use of the numerals—if he has perseverance enough—should practise now and again the repetition of a line of the multiplication table in German; as ein mal eins ist eins, one times one is one; zweimal eins ist zwei, twice one is two; zweimal zwei ist vier, twice two is four; sechsmal sechs ist sechs und dreißig, six times six is thirty-six; zehn mal zehn ist hundert, ten times ten is a hundred.

After that has been practised for a while, and has become familiar, a large number of questions might be put and answers given, observing the following forms, viz.:—Wie viel ist sechsmal sieben? How much is six times seven? Sechsmal sieben ist zwei und vierzig, Six times seven is two and forty. Wie viel ist dreimal drei hundert und drei und dreißig? How much is three times three hundred and thirty-three? Neun hundert neun und neunzig, Nine hundred and ninety-nine.

Adverbs are formed from ordinal numbers by adding the affix ens; as erstens, zweitens, drittens, &c., meaning "in the first, second, third, &c., place." As a term referring to time zuerst means at first.

The Germans have an exceedingly convenient expression,

wanting in the English language—viz. an interrogative pronoun, der wie vielte? (as it were, "the how much?") used in questions to which the ordinal numbers would give the answer; as Der wie vielte ist heute? is the question as to—"What day of the month is it?"

The following collective numbers may be mentioned:—ein Paar, a pair or couple; das Zehend, the decade; ein (or das) Dutzend, a (or the) dozen; ein halbes Dutzend, half a dozen; ein or das Schock, three score; ein halbes Schock, half a score; ein (or das) Mandel, a (or the) lot of fifteen (only used for commodities sold by tale); ein Viertelpfund, a quarter of a pound; ein Viertelhundert, quarter of a hundred.

The signification of ein Paar is not in German so strictly confined to "two" as the word *pair* in English is. It signifies both a pair (as a couple, a brace), and a few, as ein Paar Handschuhe, a pair of gloves; ein Paar Stiefeln, a pair of boots; ein Paar Wörte, two (*i.e.* a few) words; ein Paar Eier, a few or a couple of eggs; ein Paar Tropfen, a few drops; zwei Paar Enten, two brace of ducks.

Die Hälfte, the half, is derived from the adjective halb, which is either declined in the usual way—as das halbe Dutzend, or ein halbes Dutzend—or more frequently in composition with the noun das or ein Halbdutzend.

To express a distribution by parties, collective numerals are compounded with the noun weise, manner, shape, and used adverbially; as paarweise, by pairs; dutzendweise, by (as it were, in the shape of) dozens; hundertweise, by hundreds (also schaarenweise, by crowds; truppweise, in troops, &c.) With non-collective cardinal numerals the same notion is expressed in this way—einzeln, one by one; je drei und drei, by threes; je vier und vier (or also je vier), by fours; je fünf und fünf (je fünf), by fives, &c. Zu vier, zu fünf, &c., bears the meaning of "in a party of four or five," &c.

As having a close relation to the matter now engaging our attention, we may state that most of those names which express weight, measure, or number do not take the inflexion of the plural when used to denote number or quantity, &c., and are not put in the genitive, but in the same case with the preceding word; as ein Pfund Salz, a pound of salt; eine Elle Seide, a yard of silk. Both nouns stand in the case which the verb governs; for instance, Wir haben ein Pfund (*n.*) Holländischen Käse erhalten, We have received a pound of Dutch cheese.

The following are other exemplifications of this idiomatic form of construction:—

das Buch, a quire.	Sechs Buch Papier, six quires of paper
das Bund, the bundle.	Fünf Bund Stroh, five bundles of straw
das Dutzend, the dozen.	Zwölf Dutzend Aepfel, twelve dozen of apples.
der Grad, the degree.	Hundert Grad, a hundred degrees.
das Klafter, the fathom.	Neun Klafter tief, nine fathoms deep.
der Mann, the man.	Hundert Mann Reiterei, a hundred cavalry men.
die Mark, the mark.	Zehn Mark, ten marks.
das Paar, the pair.	Zwei Paar Schühe, two pair of shoes.
das Pfund, the pound.	Vier Pfund Zucker, four pounds of sugar
das Schock, three-score.	Zwei Schock Birnen, six score of pears.
das Stück, the piece.	Sieben Stück Tuch, seven pieces of cloth.
das Zoll, the inch.	Fünf Zoll, five inches.

It is only when the first of the two nouns is masculine or neuter that it does not change in the plural; feminines, especially those which express a measure of time (as die Stunde, the hour, die Minute, the minute), form their plural in the ordinary way; as Drei Pfund Salz, three pounds (of) salt; zwölf Ellen Leinwand, twelve ells (of) linen.

Similarly such sentences as the following are arranged:—

die Elle, the yard.	Sechs Ellen Tuch, six yards of cloth.
die Meile, the mile.	Sieben Meilen, seven miles.
die Tonne, the tun.	Sechs Tonnen Kalk, six tons of lime.
die Unze, the ounce.	Vier Unzen Seide, four ounces of silk.

To express the co-existence of two objects, beide, both, is used for zwei; as beide Augen, both eyes; die beiden Bruder, both the brothers. The article never stands after beide, as in English. Beide is declined like an adjective.

EXERCISE.

With the help given in parentheses, and what he has just read, the student should be able to render readily the following phrases into English:—

Wie viele Ellen Tuch (cloth) brauchen (want) Sie zu einem Ober-rocke (overcoat)? Gestern habe ich drei Tassen Kaffee getrunken. Johann, gehen (go) Sie in den nächsten Laden (shop) und holen (fetch) Sie mir 6 Pfund Käse (cheese), 3 Paar Würste (sausages), und ein Dutzend Flaschen alten wein. Die Eier (eggs) sind gegenwärtig (at present) sehr theuer (dear). Wie viel kostet das Schock? Das Schock kostet jetzt 20 Groschen. Meine Mutter hat gestern 4 Schock Eier und 6 Pfund Butter auf dem Markte (at the market) gekauft (bought). Der Thurm (tower) dieser Kirche ist mehr als siebzig Fuß hoch.

The *indefinite numerals*, aller, alle, alles, all; keiner, keine, keines, none; viel, viele, viel, many, &c., are used both adjectively and substantively (*i.e.* as pronouns), and as we have already treated them as such (on p. 338) the student should make himself familiar with them and their uses.

1. On the Stating of Dates properly.

The German mode of asking, What day of the month is it? is Den wievielsten haben wir heute? The English preposition *on*, when used before dates, is either translated by am (=an dem, on the), or by den (the accusative of the definite article); as Er starb am zehnten Mai, or den zehnten Mai, He died on the tenth of May.

Taking the following sentence as a form of reply, and the list of names of the months given below, practise, first giving the 12th of each month, the 6th, the 20th, and so on, until in the same form it is found quite easy to say or write the proper dates of any month in the year. We have to-day the 12th of March (*i.e.* To-day is the 12th of March), Wir haben heute den zwölften März. Den wievielten haben wir heute? Which day of the month is this? Heute haben wir den sechzehnten August, To-day is the 16th August. Hatten wir gestern nicht den vierzehnten? Was not yesterday the 14th?

Januar,	January.	Juli,	July.
Februar,	February.	August,	August.
März,	March.	September,	September.
April,	April.	October,	October.
Mai,	May.	November,	November.
Juni,	June.	December,	December.

In before the date of a year must be translated im (=in dem) Jahr; *e.g.* in 1887, im Jahr 1887.

It should be easy now to translate the following model sentences, and to introduce into each the proper numeral instead of the number. We have inclosed in brackets translation of words not already made familiar, and add a list of the names of the days of the week—viz.

Sonntag,	Sunday.	Mittwoch,	Wednesday.
Montag,	Monday,	Donnerstag,	Thursday.
Dienstag,	Tuesday.	Freitag,	Friday.

Sonnabend, Saturday.

These sentences will show how these names are used.

Welcher Tag ist heute? Which day is this? (literally to-day). Heute ist Montag, It is Monday (literally, To-day is Monday). Welcher Tag wird morgen sein? Which day will to-morrow be? Morgen wird (es) Dienstag sein, To-morrow (it) will be Tuesday. Welches sind die übrigen Tage der Woche? Which are the remaining (*i.e.* other) days of the week? Mittwoch, Donnerstag, Freitag, Samstag, und Sonntag. Er ist letzten Freitag angekommen, He arrived last Friday. Wann wird er abreisen? When will he depart? Er wird nächsten Dienstag abreisen, He will depart next Tuesday. Warum bleibt er nicht bis Mittwoch oder Donnerstag? Why does he not stay till Wednesday or Thursday? Er kann nicht länger bleiben; er hat Geschäfte, He cannot stay longer; he has business.

Es war am 15. Januar. Sen wievielsten hatten wir gestern? (yesterday, Scottice yestreen). Wir haben heute den 6. November, also hatten wir gestern den fünften. Es war am Mittwoch den 10. März als (when) er kam. Dein Brief (his letter) ist

vom fünf und zwanzigsten Februar 1889 datirt. Ich bin am 4. August 1832 geboren (born). Mein Geburtstag (my birthday) ist am 11. März 1844. Er wurde am 14. August 1865 geboren. Ludwig der vierzehnte starb (died) im Jahre 1774. Ludwig der sechzehnte starb im Jahre 1793. Peter der Große (the Great) wurde am 11. Juni 1677 geboren, er starb am 8. Februar 1720. Es ist sein siebenzigster Geburtstag. Es war in der vorletzten (before the last) Woche. Er ging am letzten Montag nach Frankreich. Er war der erste in der Klasse.

2. On the Reckoning of the Time of the Day
(*i.e.* in telling or asking what o'clock it is).

The word die Uhr signifies the clock, watch, hour, time.

Wieviel Uhr ist es? / Was ist die Uhr? / Was ist die Zeit?	what is the time? (*i.e.* what o'clock is it?)
Es ist ein Uhr,	it is one o'clock.
Es ist zwei Uhr,	it is two o'clock.
Es ist sechs Uhr,	it is six o'clock.
Es ist zehn Uhr,	it is ten o'clock.
Es ist zwölf Uhr,	it is twelve o'clock.
Es ist fünf Minuten nach zwei,	it is five minutes past two.
Es ist ein Viertel auf drei,	it is a quarter past two.
Es ist halb sechs,	it is half-past five.
Es ist drei Viertel auf acht,	it is a quarter to eight.
Es ist in zehn Minuten sieben,	it wants ten minutes to seven.
Es ist halb elf (nach meiner Uhr),	it is half-past ten o'clock (by my watch).
Die Uhr schlägt zehn,	the clock strikes ten.

The fractional part, half, it must be noticed, is always expressed in German by the next higher number in degree; thus instead of saying half-past three, speaking of the hour the Germans say half-four, halb vier. So for half-past twelve they say half-one, halb eins; for half-past one, halb zwei; for half-past two, halb drei, &c.

But to indicate the quarters of an hour they use the word Viertel, and name the next hour with the preposition auf; *e.g.* Ein Viertel auf zehn, a quarter towards ten (quarter past nine); es ist drei Viertel auf Eins, it is three-quarters towards one (*i.e.* it wants a quarter to one).

The following sentences may now be translated, and after the same manner the student may compose many sentences, changing in each the words employed to denote the time:—

Es ist so eben (just now) drei Uhr. Es hat vier Uhr geschlagen (struck). Ist es schon (already) halb neun? Nein, es fehlen (wants) noch fünf Minuten zu halb. Es ist erst zwanzig Minuten nach sieben. Es fehlen noch fünf und zwanzig Minuten zu neun. Es ist drei Viertel auf sechs. Es ist halb zehn vorbei (gone). Es ist elf Uhr vorüber (past). Ist es schon halb sieben? nein, es ist erst ein Viertel. Es hat so eben drei Viertel auf eins geschlagen. Es ist zehn Minuten auf drei. Es ist in zehn Minuten drei Uhr. Es schlägt so eben zwölf Uhr. Es ist sechs Minuten nach zwei Uhr.

EXERCISES.

With a very little help (furnished in parentheses) on the first appearance of the word, the student will find it easy to discover the signification of the following sentences, and to use them as models for making similar statements involving the mention of numbers. He will find it advantageous to turn to the declensions of nouns that he may note the cases and numbers of those occurring in these exercises.

Die Woche hat sieben Tage. Der Tag hat zwölf Stunden. Die Stunde hat sechzig Minuten. Der Monat hat dreißig, zuweilen (sometimes) ein und dreißig Tage. Im Jahre 1815. Zwei mal zwei ist vier. Fünf mal sechs ist dreißig. Das Jahr hat drei hundert fünf und sechzig Tage. Mein Vater hat neun und zwanzig Ochsen, fünf und fünfzig Kühe, und 3705 Schäfe.

In unserm Hause sind vierzehn Zimmer (rooms). In diesem Zimmer sind zwei Tische (tables) und zwölf Stühle (chairs). Unser Nachbar (neighbour) hat fünf Kinder: drei Söhne und zwei Töchter. Wir haben vier Katzen (cats) und drei Hunde (dogs). In eurem Garten sind fünfzehn Bäume. Das Jahr hat zwölf Monate; der Monat hat vier Wochen. Ich habe von meinem Vater sechs Aepfel und acht Birnen erhalten (received).

Dieses Fenster hat zwölf Scheiben (panes), jenes nur acht. Ein Thaler hat dreißig Silbergroschen. Ein Schilling hat zwölf Pfennige. Ein Pfund hat zwanzig Schillinge. Vier Pfund sind einhundert und acht Loth (half-ounces). Ich bin der siebente in der Klasse. Heut ist der zwölfte April. Der ein und zwanzigste April ist mein Geburtstag. Mein Bruder wurde am sechs und zwanzigsten April geboren. Sie finden es (you find it = it is found) im Propheten Jesaia im acht und vierzigsten Capitel und siebzehnten Vers.

Er sich zwischen Stühle setzt (he places himself between two stools). Mein Bruder ist schon drei Jahre in Berlin. Haben Sie noch nicht gegessen? Ich habe schon seit drei Stunden gegessen. Ist Ihr Vater noch nicht angekommen? Er ist schon seit zwei Tagen angekommen. Mein Onkel ist seit vier Monaten krank; er hat seit acht Tagen nichts gegessen. Mein Bruder ist neun Jahre alt, aber meine Schwester ist noch nicht sieben Jahre alt.

Ein gewöhnliches (common) Jahr hat 365 Tage, und ein Schaltjahr (leap year) hat 366 Tage. Die Monate Januar, März, Mai, Juli, August, Oktober, December haben jeder 31 Tage; von den Monaten April, Juni, September, November hat jeder 30 Tage; und Februar hat in einem gewöhnlichen Jahr 28 und in einen Schaltjahr 29 Tage.

EXERCISE IN READING.

The following simple little story contains a considerable number of common German phrases and idioms. We subjoin an alphabetical phrase translation, which the student will find easy to write down so as to form a complete version of the tale. It would be advisable for the student to examine carefully the nouns and adjectives, and to note how their terminations indicate gender, number, and case.

Der gestohlene Heller.
(The Stolen Farthing.)

Es saß einmal ein Vater mit seiner Frau und seinen Kindern Mittags am Tische, und ein guter Freund, der zum Besuch gekommen war, aß mit ihnen. Und wie sie so saßen, und es zwölf Uhr schlug, da sah der Fremde die Thür aufgehen, und ein schneeweiß gekleidetes, ganz blasses Kindlein hereinkommen. Es blickte sich nicht um und sprach auch nichts, sondern ging geradezu in die Kammer neben an. Bald darauf kam es zurück und ging eben so still wieder zur Thüre hinaus. Am zweiten und am dritten Tage kam es auf eben diese Weise. Da fragte endlich der Fremde den Vater, wem das schöne Kind gehörte, das alle Mittag in die Kammer ginge. „Ich habe es nicht gesehen," antwortete er, „und wüßte auch nicht, wem es gehören könnte." Am andern Tage, wie es wieder kam, zeigte es der Fremde dem Vater, er sah es aber nicht und die Mutter und die Kinder alle sahen auch nichts. Nun stand der Fremde auf, ging zur Kammerthüre, öffnete sie ein wenig und schaute hinein. Da sah er das Kind auf der Erde sitzen und emsig, mit den Fingern in den Dielenritzen graben und wühlen; wie es aber den Fremden bemerkte, verschwand es. Nun erzählte er, was er gesehen hatte, und beschrieb das Kind genau, da erkannte es die Mutter und sagte: „ach, das ist mein liebes Kind, das vor vier Wochen gestorben ist." Sie brachen die Dielen auf und fanden zwei Heller, die hatte einmal das Kind von der Mutter erhalten, um sie einem armen Manne zu geben, es hatte aber gedacht: „dafür kannst du dir einen Zwieback kaufen," die Heller behalten und in die Dielenritzen versteckt; und da hatte es im Grabe keine Ruhe gehabt, und war alle Mittage gekommen, um nach den Hellern zu suchen. Die Eltern gaben darauf das Geld einem Armen, und nachher ist das Kind nicht wieder gesehen worden.—Grimm.

VOCABULARY.

ach, ah!
alle, all.
alle Mittag, or Mittage, every noon, *i.e.* every day at noon.
am (for an dem), at the.
Am andern Tage, on the next day.
am dritten, on the third.
am Tische, at table.
am zweiten, on the second.
antwortete er, he answered; from antworten, to answer.
arm, poor.
aß, was eating; essen, to eat.

auch, also.
auf eben diese Weise, just in the same manner.
aufgehen, to go up, open.
auf der Erde, on the ground.
bald darauf, soon afterwards.
beschrieb, described; beschreiben, to describe.
da, then (so).
dafür, for that.
darauf, thereupon, then.
das, that, which (rel.)
das Geld, the money.
das ist, that is.
das Kind, child, pl. die Kinder.
das Kindlein, little child.
das Kind sitzen, the child sitting.
das schöne Kind, the beautiful child.
der Fremde, the stranger.
der Freund, friend.
der gekommen war, who had come.
der Heller, small copper coin.
der Mann, man.
der Tag, day.
der Tisch, table.
die, which.
die Diele, deal, board, plank.
die Eltern, the parents.
die Frau, wife, woman.
die Heller, the farthings.
die Kammer, chamber, room.
die Kammerthüre, the chamber door.
die Mutter, the mother.
die Mutter erkannte es, the mother knew it; erkennen, to know, recognise.
die Ritze, rift, crevice.
die Ruhe, rest.
die Thür, the door.
die Weise, way, wise.
dir, for thyself.
eben, even, just.
einem Armen, to a poor man.
einmal, once.
ein Vater, a father.
ein wenig, a little.
ein Zwieback, a biscuit.
emsig, diligently, busy, busily.
endlich, at length, at last.
er sah es aber nicht, but he saw it not.
erzählte er, he told.
es blickte sich nicht um, it looked not round.
es hatte aber gedacht, but it had thought; denken, to think.
es hatte gehabt, it had had.
es saß, there sat; sitzen, to sit.
es schlug, it struck; schlagen, to strike.
fanden, found; finden, to find.
fragte, asked; fragen, to ask.
gaben, gave; geben, to give.
ganz blaß, quite pale.
geben, to give.
gehörte, belonged.
gekleidet, clothed, dressed.
genau, exactly.
geradezu, directly.
gestohlen, stolen; stehlen, to steal.
gestorben ist, died; sterben, to die.
ging, went; gehen, to go.
ginge, went.
ging hinaus, went out.
graben, to dig, to grave.
gut, good.
hatte behalten, had kept.
hatte erhalten, had received.
hatte versteckt, had concealed.
hereinkommen, to enter.
ich habe es nicht gesehen, I have not seen it; sehen, to see.
im Grabe, in the grave.
in den Dielenritzen, in the crevices of the flooring.
ist nicht gesehen worden, has not been seen, was not seen.
kam es, it came; kommen, to come.
kam es zurück, it came back.
kannst du kaufen, thou canst buy.
kein, no.
mein liebes Kind, my dear child.
mit, with.
mit den Fingern, with the (its) fingers.
mit ihnen, with them.
Mittags, at noon, midday.
nach, after.
nachher, afterwards.
neben an, near, adjoining.
nichts, nothing.
öffnete sie, opened it.
Nun, now.
sagte, said; sagen, to say.
sah, saw; sehen, to see.
sahen, saw; sehen, to see.
sah er, he saw; sehen, to see.
schaute hinein, looked in.
schneeweiß, snowwhite.
sein, his.
sie, them.
sie brachen auf, they broke up; aufbrechen, to break up.
sondern, but.
sprach, spoke; sprechen, to speak.
stand der Fremde auf, the stranger arose; aufstehen, to rise, stand up.
still, still, quietly.
suchen to seek, search.
um — zu, in order to.
verschwand es, it disappeared; verschwinden, to vanish.
von der Mutter, from the (its) mother.
vor vier Wochen, four weeks ago.
war gekommen, had come.
was er gesehen hatte, what he had seen.
wem, to whom.
wem es gehören könnte, to whom it could belong.
wieder, again.
wie es aber bemerkte den Fremden, but when it observed the stranger.
wie es weider kam, when it came again.
wie sie so saßen, as they so sat.
wühlen, to rake, rummage.
wußte, knew; wissen, to know.
zeigte es, showed it; zeigen, to show, to point out.
zur (for zu der), to the.
zum Besuch, on a visit.
zwei, two.
zwölf, twelve.
zwölf Uhr, twelve o'clock.

ENGLISH GRAMMAR AND COMPOSITION.

CHAPTER VIII.

THE UNINFLECTED PARTS OF SPEECH—ADVERBS, PREPOSITIONS, CONJUNCTIONS, &c.

On examining almost any ordinary sentence we find that the words of which it is made up are connected one with another, not only in position, but also by some relation, according to which they are said by grammarians to agree with or depend upon each other. The relations of things are very numerous, and many of these are continually changing. If we were to have a separate word for every possible change of relation their number would overload the memory, their minute distinctions would embarrass thought, and therefore the ready use of them would be difficult. To obviate, as far as practicable, the inconveniences of such a mode of indicating the numerous relations of things through their representative words, men have, in many languages, distinguished several of the changes which befall things by the logical term *accidentia* (*i.e.* alterations which take place in them not of necessity, but contingently and by possibility). On this account that part of grammar which deals with the changes which occur in words is called *the accidence.* Such words as undergo changes in their form as indicative of changes in their signification and in their suggestion as regards relation, are said to be *inflected* (Lat. *flecto*, I bend), *i.e.* varied from their ordinary—what might be called their *straightforward* form—in order to indicate that the mind is to consider them in a rather altered relation. For instance, in the sentence, "I bought a dog," the verb *bought* has been inflected to suggest that the act of *buying* is accomplished and past, therefore it appears in the past tense, and the word *dog* retains its usual meaning. But in the sentence, "I bought a dog's collar," the word *dog* has altered its form because it has altered its signification, and now means "for, suitable to, of a kind that is worn by a dog." In this way it is said to be *declined* (Gr. *klino*, I cause to slope or slant), *i.e.* to have been put into an *oblique* case —one which indicates that the word is to be looked on as possessing a different meaning from what it does in the *nominative* or the *objective*, in which cases it directs the mind to an animal spoken of or one acted upon. Many of the relations of things were, however, felt to be distinctly diverse, capable of being regarded by the mind as clear, obvious, and different aspects of things, and expressed in words conveying a sufficiently plain and perceptible signification, and so requiring little (if any) modification of form. These words remain for the most part unchanged, and are designated *indeclinable* or *uninflected* parts of speech, such as occur in the sentences—I *recently* bought a dog; I bought a collar *for* a dog; I bought a dog *and* a collar; *Alas!* I bought a dog. It is with such uninflected parts of speech that we have now to deal.

There are four classes of indeclinable words, viz., adverb, preposition, conjunction, and interjection.

ADVERBS.

These are so called because they most usually influence, affect, or modify the meaning of verbs, and superimpose, as it were, upon the assertion or predication they make, some change of meaning. "I was" is an absolute statement. "I was there" is probably no less absolute, but is much more specific. It is because of this effect produced by them in the modification of the statements which verbs convey, and the help they thus give to accuracy of expression as a precise representation of thought, that Dr. J. W. Donaldson advances the view that "their syntactical use is as secondary predicates." As a matter of fact the verb, as its name implies, either "immediately or mediately," as B. H. Smart has said, "absorbs every other part [of speech], and indicates that the one expression with one meaning which arises out of the absorption is complete. The whole sentence is then the word—that is, the verb." Of all words it has the greatest affinity for the verb. "It is," as Professor John Earle says, "the peculiar companion of the verb, as the adjective is of the substantive." As an assistant to and adjunct of the verb, the adverb has received its name. Besides limiting or modi-

fying the meaning of verbs they also affect the signification of adjectives and other adverbs, even prepositions and phrases, &c. In "I came gladly," the verb *came* is modified by the adverb *gladly;* in "she is very poor," the adjective *poor* is intensified by the adverb *very;* in "you are exceedingly often there," *there* is affected by *often* and that by *exceedingly;* in "they were much behind time," *much* increases the force of the preposition *behind;* in "he gave me only a sixpence" [*i.e.* nothing more than], *only* modifies the article *a*, equivalent to the numeral adjective *one;* but in "he gave me only [*i.e.* nothing else but] sixpence," it seems to qualify the noun sixpence. A large number of adverbs contain their meaning within themselves, and are therefore simple in their form and absolute in the notion they convey, *e.g.* now, there, soon, humbly, &c.

As to *form*, some adverbs are *compound*, *e.g.* likewise, forthwith, peradventure, beyond a doubt, &c.; and as to the notion they convey only relative, *e.g.* when, where, while, how, why, &c.

Their relative adjectives do somewhat more than modify the meaning of the verb, adjective, or phrase with which they are used. They connect the clause in which they occur with the rest of the sentence—*e.g.* I will go when you are ready; It is of importance to learn whither he has gone. We shall see hereafter that there are many conjunctions which, as they refer to time, place, manner, &c., there is some danger of mistaking for adverbs. But such conjunctions never refer to those adverbial conditions in connection with any verb or adjective in the clause—always a subordinate one—which they are specially employed to introduce. They, in fact, transform the entire clause in which they are used to an adverbial phrase—*e.g.* I gave him help because I believed (= was in the belief that) he was in want. On this account we supply a pretty full and accurate list of all these relative or (as they might otherwise be called) connective or conjunctive adverbs—in most of which it will be seen that there are etymological signs of their origin from (or at least common origin with) the relative pronouns who, which, and what:—Why = what by; while = time, at which or what time—its stronger form is whilst; where = which then; as also wherein, whereon, whereat, whereout, whereafter, wherever, whereby, wherefore, and whereof; when and whence; whither = which, hither, or thither; so (when it corresponds with as, so, such); that (after so and such), than, then, thence, and the (in such sentences and phrases as, The more you learn, the wiser you will become; So much the better). Many of these relative adverbs may also be used interrogatively—*e.g.* when did you arrive? whence did you come? whither do ye go? wherefore are ye sad? &c. The adverbs anywhere, elsewhere, nowhere, do not retain their relative force.

In another point of view adverbs might be classed as (1) *Static, i.e.* indicative of the state or condition of the thing to which the verb refers; *e.g.* The boy was *sickly;* He is an *only* son; *How nicely* these flowers look; The cup is *quite* safe. (2) *Modal*, signifying manner; *e.g.* He walks *fast*, writes *slowly*, reads *aloud*, and sums *well*. (3) *Limitative*, (i.) as to place, (ii.) time, (iii.) direction, (iv.) relation, (v.) demonstration, and (vi.) representation; *e.g.* aloft, lately, backward, whence, there, as, and so. (4) *Graduative*, (i.) equality, (ii.) excess, (iii.) diminution, and (iv.) repetition; *e.g.* exactly, enough, far, ever so, scarcely, almost, again, often. But the most practically useful method of classification—if we always remember that, by analogy, words of one class may often be used instead of those of another—is that which we now proceed to make.

I. Place: (1) of rest in, (2) of motion to, (3) of motion from, (4) separation, (5) conjunction, and (6) relation.

(1) *Rest in*, as here, there, where, above, below, whereabouts, everywhere, somewhere.

(2) *Motion to*, as hither, thither, whither, and their compounds hitherward, thitherward, whitherward; also inwards.

(3) *Motion from*, as hence, thence, whence, outwards, forth, forthright, straightforwardly.

(4) *Separation*, as apart, asunder, afield, separately, away, off, mediately, elsewhere, nowhere.

(5) *Conjunction*, as near, by, besides, together, next, to and fro, inside, immediately, at home.

(6) *Relation*, as upwards, aboard, downwards, sideways, aslant, forwards, backwards, around, closely, outwith, alongside, yonder, further, headlong, over head and ears.

II. Time: (1) present, (2) past, (3) future, (4) duration, (5) repetition.

(1) *Present*, as now, instantly, presently, forthwith, henceforth, still, currently, to-day, now-a-days, already, meantime, at this moment, for the nonce, extempore, immediately, at once, just now.

(2) *Past*, as before, once, lately, heretofore, beforehand, hitherto, already, yesterday, whilom, erewhile, anciently, previously, antecedently, immemorially, preceding, ere now, ere yet, prefatorily, prelusively, formerly, up till now, once upon a time.

(3) *Future*, as afterwards, soon, anon, by and by, to-morrow, at hand, forthcoming, henceforwards, hereafter, in process of time, sooner or later, no more, subsequently, in the long run, all in good time, ulteriorly.

(4) *Duration*, as always, ever, never, continually, continuously, eternally, incessantly, perpetually, aye, forever and aye, all the day long, all the year round, evermore, from age to age, permanently, persistently, awhile, all the while, all along, throughout, meanwhile, for a season, temporarily, simultaneously, concurrently, suddenly, abruptly, punctually, betimes, apace, ofttimes.

(5) *Repetition* (or recurrence), as seldom, rarely, scarcely, hardly ever, infrequently, sometimes, not often, once in a way, occasionally, once and again, intermittently, at times, alternately, oft, often, many a time and oft, frequently, not unfrequently, periodically, recurrently, repeatedly, many times over, capriciously, desultorily, daily, hourly, monthly, annually, centennially, afresh, anew, statedly, gradually, consecutively, by the way, by fits and starts, reciprocally, how oft (or often), so often, too frequently.

III. Number and Order.—Once, twice, thrice, &c.; simply, singly, doubly, triply, &c.; firstly, secondly, thirdly, &c.; twofold, threefold, fourfold, &c.; first, foremost; after that, in succession, by turns, next, last, numerically, orderly, ordinately, methodically.

IV. Quantity and Degree.—Exceedingly few, very little, slightly, scarcely, inconsiderably, almost, pretty, moderately, quite, sparingly, enough, highly, sufficiently, much, far, too much, very much, greatly, exceedingly, utterly, generally, thoroughly, universally, partly, well-nigh, nearly, exactly, perfectly, more, less, better, worse, piecemeal, plentifully, gradually, somewhat large, rather little, too few, in general.

V. Affirmation (belief), Negation (disbelief), Doubt (uncertainty).—(1) Actually, credibly, certainly, certes, surely, truly, verily, really, assuredly, undoubtedly, of course, sure enough, indubitably, exactly, precisely, positively, by all means, indeed, in sooth, in truth, as sure as fate, even so, just so, ay, yea, yes; (2) no, not, nay, nowise, not a jot, not a whit, by no means, in no respect, not at all; (3) maybe, likely, perhaps, haply, perchance, peradventure, probably, possibly, for aught one knows, feasibly, plausibly, equivocally, problematically, dubiously.

VI. Cause and Effect (or ratiocination).—How, why, in what manner, by what means, therefore, wherefore, accordingly, consequently, for, because, on which account, forasmuch as, in conclusion, whereas, so that, if so.

VII. Comparison.—As, so, also, likewise, too, solely, merely, so as, as if.

VIII. Quality and Manner.—Adjectives indicate the qualities of things, and we may very frequently require to indicate the possession of something like these qualities—*e.g.* wise, wise-like, wisely; quick, quick-like, quickly; true, true-like, truly, &c. In this way we can transform almost every adjective into an adverb. Verbs, as they imply actions, must frequently (that accuracy of speech may be maintained) require that the special manner in which the actions are performed should be stated or indicated. We walk swiftly, slowly, straightly, rightly, hurriedly, easily, toilsomely; we speak lowly, loudly, sharply, earnestly, carelessly, long, eloquently, disjointedly, pleasingly, &c.; and every word we so use to characterize the manner or mode in which the actions or assertions mentioned by verbs are to be thought of as modified is an adverb. We can thus add very largely to the

vocabulary of our language, and very greatly to the accuracy and specific expressiveness of our speech. It is impossible therefore to make a list of such adverbs: they are far too numerous to be arranged in a catalogue. The adverb is the product of a rather more refined operation of the mental faculties than the adjective; the latter lies nearer the concrete fact; the former, by a fine exercise of analogy, regards many things as possessed of a less or greater resemblance one to another, and expresses this in an abridged form of the adjective *like*.

When a noun or an adjective is used for an adverb, Professor Earle proposes to designate or classify it as *flat; e.g.* Wonder great; villainous low; an extraordinary good book. When the case of a noun is used as an adverb he would call it *flexional; e.g.* His honours are but of *yesterday's* growth; He squeezed in *edgewise;* He did it *piecemeal*, &c.

The third form of adverb he classifies as *phrasal, i.e.* consisting of a phrase like "not grudgingly or *of necessity.*" *Willingly* is a simple adverb; *with goodwill* is a phrasal one. It is, indeed, highly probable that all our simple adverbs are remnants of such phrases gradually condensed; for example, "in an earnest-like manner" into *earnestly*, and so on. The modern view of adverbs is that they are derivative forms of nouns, adjectives, pronouns, phrases, &c., now used to qualify or modify the idea contained in adjectives and verbs when regarded as predicates.

Some adverbs, like the adjectives from which they are derived, or from their retaining a good deal of their adjectival character, are compared; as,

Often,	oftener,	oftenest.	Seldom,	seldomer,	seldomest.
Soon,	sooner,	soonest.	Quickly,	quicker,	quickest,
Early,	earlier,	earliest.		*or* more quickly,	most quickly.
Fast,	faster,	fastest.	Slowly,	more slowly,	most slowly.
Ill *or* badly,	worse,	worst.	Happily,	more happily,	most happily.
Well,	better,	best.	Usefully,	more usefully,	most usefully.

Some adverbs being derived from adjectives which have no positive have a similar deficiency; as, *extremely* useful, &c.

PREPOSITIONS.

Prepositions are words indicative of relation, primarily of place; but this has, by analogy, been largely extended to other relations of time, cause, extension, interest, &c. They are not numerous, but they are very frequently used, and their significations, when wisely distinguished by acute minds, are exceedingly various, although they may all be traced back to their original reference as to place. It would be quite easy to write a book of considerable size on the minutely varied shades of meaning which prepositions take and have taken in the course of the progressive development of the English language. Prepositions receive their name from their being (as a general rule) placed before the nouns, whose relations to some other words require to be stated; *e.g.* John's house is on a slope beside the river, with a hill rising behind it, and trees growing in the lawn before it.

Many prepositional phrases are employed—chiefly, however, for the secondary relations of thoughts rather than things. They may be classed as referring to (1) *agency*, *instrumentality*, or *means*, *e.g.* by means of, by virtue of, by help of, by force of, &c. (2) *Purpose, motive*, or *reason*, *e.g.* on account of, with a view to, for the sake of, from a regard to, by way of, in consideration of, on the score of, &c. (3) *Reference, e.g.* as to, as for, as regards, on the subject of, in point of, in respect of, as touching, so far as concerns, with reference to, in allusion to, in case of, in the event of, resulting from, &c. (4) *Separation* or *exclusion*, *e.g.* setting aside, apart from, far from, without regard to, other than those of, &c. (5) *Contrariety* or *opposition*, *e.g.* in spite of, notwithstanding all that, in defiance of, inconformably to (or with). (6) *Substitution, e.g.* instead of, in place (or room) of, on the part of, in lieu of, in substitution for. (7) *Conformity* or *agreement*, *e.g.* according to, in compliance with, at the suggestion of, in harmony (or accordance) with, agreeable to, in conformity with, in pursuance of. (8) *Possession, material*, &c., *e.g.* belonging to, the property of, made (or composed) of.

Prepositions in English are always placed before their nouns or pronouns, except (and that mostly colloquially) in the case of relative pronouns expressed or understood; as The book [that] I spoke about is published. It was John I referred to (=to whom I referred). The man I rode with (=with whom I rode) told me so.

An endeavour has been made in the following table to give a complete list of the prepositions, and at the same time to indicate with some degree of distinctness the special signification each implies:—

Table of Prepositions.

Amid, Amidst, Among, Amongst, Within		Encircled.
About, Around, Round		Encircling.
Across	Motion or Progress	
Athwart	Motion or Progress	Slanting.
Against	Motion or Progress	Hostile.
From	Motion or Progress	Distant sources.
Of	Motion or Progress	Near sources.
Through	Motion or Progress	By means.
For, To, Unto	Motion or Progress	Having an end in view.
Towards	Motion or Progress	
Along	Motion or Progress	Straightforward.
Concerning, Regarding, Respecting, Touching		Connection, mental or physical.
Since	Time	Past.
By	Time	Future.
During	Time	Continuous.

On	Resting	Slightly.
Upon	Resting	Heavily.
Up	Altitude	Detached
Above	Altitude	More do.
Over	Altitude	Most do.
After, Since, Behind, Beyond	Skirted	
By, Beside, Near, Nigh, At, With	Close proximity.	
Except, Excepting, Without, Save	Exclusion.	
Below, Beneath, Down, Under, Underneath	Depth.	
Between, Betwixt	Interception.	

CONJUNCTIONS.

Conjunctions join together words, phrases, clauses, and sentences. The primary purpose of conjunctions is to unite in thought two (or more) distinct affirmations, and therefore the thoughts so coupled must be similar in construction. Conjunctions are a comparatively modern grammatical product. As their office is to connect sentences, they presuppose that complete sentences have been formed, and that they require to be related in some *added* form one to another. They may be best arranged in accordance with the four laws of mental association—viz. (1) juxtaposition, or nearness to one another; (2) resemblance, or likeness one to another; (3) contrast, or unlikeness; and (4) succession, or relation in time, place, order, cause, &c. A list follows exhibited in this way:—

Table of Conjunctions.

I. Juxtapositive	II. Resemblant	III. Contrastive	IV. Successive
And	As	Or	Because
Both	So	Nor	For
Likewise	As well as	Either	If
Also	Such	Neither	Then
Too	Same	Although	Since
		Yet	Seeing
		But	Notwithstanding
		Except	Even
		Lest	That
		Whether	Nevertheless
		Than	Unless
		Save	Therefore
		Whereas	Provided
		Even	Wherefore

Conjunctions—especially those which consist (or consisted originally) of phrases—might be etymologically arranged according to the words from which they are derived, as (1) *substantival*, *e.g.* sometimes the one and sometimes the other; while (= at the same time that) we delay opportunity flies; otherwise (= in other ways); likewise (= in a similar way); on the one hand . . . on the other hand; on the contrary; in case; upon condition; at times; because (*i.e.* by cause); besides (by sides); on purpose that, &c.; (2) *adjectival* (or adverbial), *e.g.* accordingly, alike, anon, consequently, directly, even, finally, furthermore, lastly, lest, more-

over, namely, now . . . now, only, partly . . . partly, unless; (3) *pronominal*, *e.g.* also, although, and, as, as far as, either, neither (or, nor), hence, how, just as, lest, no sooner than, so, then, than, that, therefore, though, whence, whether, whereupon, &c.; (4) *numeral*, *e.g.* both, first, firstly, &c.; (5) *verbal*, considering, except, excepting, save, saving, providing, say, suppose, *videlicet*, to wit, &c.; (6) *prepositional*, *e.g.* after, but (=be out), before, ere, for, since (sith, sithence), that, till, until, &c.

INTERJECTIONS, by their name, indicate that they are no part of the composite material with which sentences are built up. They are thrown in between words or sentences as emotion prompts, without entering into their structure. In rhetorical discourse exclamation holds a prominent place. It uses almost any word or phrase with an interjectional force—*e.g.* halt! attention! hark! what! ah me! how strange! hallelujah! &c. There are, however, definite recognized sounds indicative of emotions used in animated conversation, rhetorical composition, and poetry, which are well known, and may be registered and classified. The interjections of (1) *approbation* are, bravo! well done! (2) *aversion*, pooh! pugh! tush! (3) *grief*, oh! ah! alas! (4) *joy*, hurra! huzza! (5) *contempt*, pshaw! fie! (6) *laughter*, ha! hah! ha-ha-hah! (7) *surprise*, la! oh la! (8) *wonder*, O! hah! Those used to excite attention are, behold! hark! hush! look! see!

The definition, analysis, classification, inflexions, and conjugations of the several parts of speech have now been set before the student as single words. To know these facts regarding such single words is of great importance. Grammarians have generally arranged a series of excellent exercises by which the accuracy and completeness of the learner's knowledge of these facts may be tested, under the technical division called *parsing*. For the attainment of proficiency by practice in this we shall give some instructions shortly. There remains, after these rudiments have been properly acquired, the grouping of words (1) in grammatically correct form, which is taught under the name of *syntax;* and (2) in literary form, as connected and arranged thought rightly and consistently expressed, which is usually explained under the designation of *style*—though it also admits of a threefold consideration under the heads of *composition*, *oratory*, and *rhetoric*. All these have to do with the ordering and arranging of words so as to express thought in the most correct, pleasing, and effective forms and phrases. We have, as yet, been only preparing for those higher accomplishments of speech, in the achieving of which we hope to aid our readers.

GEOLOGY.—CHAPTER VIII.

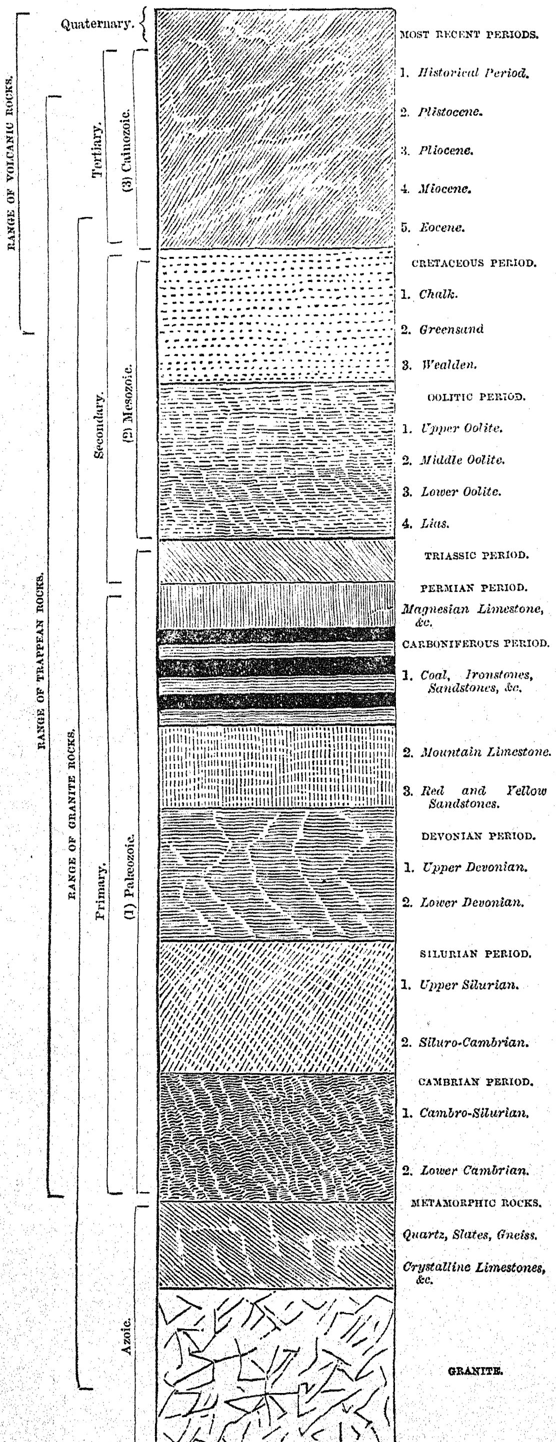
STRATIFICATION—CLASSIFICATION AND SUCCESSION OF ROCKS—FUNDAMENTAL FACTS, ETC.

IN the history of the earth and the endeavour to describe its geological structure, the terms *strata* and *formation* frequently recur. They have not, however, been always employed with scientific exactness. Rocks which are observed to consist of distinct layers, lying one over the other for a considerable extent, are said to be stratified—*i.e.* arranged in beds, as if the abraded materials of the older rocks had been spread out and rearranged, having been washed down into water, through which they gradually fell as sediment. When such beds formed of the same material are found, each is called a *stratum*, and a collection of strata, agreeing in their origin and composition, and bearing the appearance of having a similar age, or of having been formed under the same sort of conditions, is called a *formation*. This term has been used to denote a single similar series of deposits, but it is now found advisable to restrict its use to a group of strata formed during special periods, in which the arrangement of sea and land, climate and circumstance, had a certain degree of sameness, and indicating in their disposition and contents some of the more remarkable of the mutations in the condition of the globe which induce alteration of the phenomena taking place in the outer crust of the earth. Such groups of rocks are found by the cultured eye of the student of nature to possess characteristics which mark them off one from another—whether underlying or overlying them—and which are sufficient to distinguish them in whatever portion of the telluric surface they are seen. A formation contains a system of strata capable of collocation and grouping in a categorical or distinct and orderly array in the mind, as well as of being described and classified by clear and natural characteristic marks. A system of formations is distinguished as a *group*, although it has been very usual to apply the term *periods* or *epochs* of geological time to the great assemblages of strata which exhibit in their superimposed layers or deposits a considerable number of mineral characteristics and of fossil remains in common—the principle of the classification being that the greater the amount of likeness and the more numerous the points of similarity in these masses, the more probably are they of nearly the same age, or of an age so closely approximating in general feature and conditions as to be capable of being virtually regarded as belonging to one great era of geological evolution.

Of course systems of classification differ according to the object in view, and there may be not only a different nomenclature (or collection of names made use of in geology as in any other special science), but a different mode of looking at phenomena employed. There is, for instance, phenomenal, descriptive, or historical geology, which aims at tracing not only the composition of the different materials of which the crust of the earth consists, but also the method and the circumstances under which the changes or evolutions seen in its formations have occurred in the past ages of the globe's existence; and there is physical (or rather theroetical) geology, which does not content itself merely with a knowledge of what changes have supervened in the past, but desires to comprehend the causes of such changes, and to group together all that can be learned from the researches of various investigators that may aid in determining the laws of such changes. Any representation of phenomena, to be really instructive and interesting, in a scientific point of view, must be systematic, and must, therefore, adopt some classification which implies a more or less accurate and natural method of looking at these matters as a connected whole. While all geologists agree in considering the rocks and other materials which occupy their attention as divided into successive layers or strata, superimposed upon one another ideally, yet really disrupted, bent, and full of faults, fissures, inconformabilities, &c., some direct their minds more to the history of the stratification and the periods to which they may be referred, while others devote their investigations to the causes and means by which the stratification has been brought about. The latter seek to determine the conditions and circumstances to which phenomena are due, and they classify the rock-structures which they study stratigraphically thus:—1, Unstratified, which are (1) igneous, and (2) metamorphic; and 2, Stratified, which are (1) organic in their derivation—*e.g.* chalk, coals, &c.; (2) chemical in their origin—*e.g.* rock-salt and sinter; and (3) mechanical in their formation—*e.g.* shale, sandstone, and conglomerates. The former look on the several strata as so many leaves of Nature's autobiography, and they endeavour to decipher and elucidate the history which Time has written at her dictation on those stony pages. Though they find the perusal difficult, and the record here and there imperfect, yet they feel the interest of its disclosures, and are charmed with the immense vista of change, progress, evolution, and marvel disclosed to their researches.

Fact is the foundation of science, but thought is the architect of the structure. With patient toil and persevering care facts capable of ocular proof and measurement must be accumulated; with greater caution and thoughtfulness must causes be examined and theories tested; but when thought and fact concur in implicit and in explicit harmony the result is scientific truth. It is in such a fashion that the geologist tries to reconstruct the successive ages of the life of our planet, and to decipher from the autobiographic records of the past the history of the globe. He uses for this purpose the facts of the fossiliferous flora and fauna which the rocky archives of the earth have preserved and arranged for investigation. The stupendous and varied phenomena of geologic fact, and the singularly pertinent and subtle manner in which chemical laws, mechanical forces, geometrical ratios, and mathematical generalizations have all

been brought to bear upon the explanation of these facts, make it all but certain that the geological ideal of the past is pretty nearly what would be found were it possible by some unheard-of might of machinery to sink a shaft through



Ideal Section showing the succession of the Great Epochs, and the range of the so-called Igneous Rocks.

the earth's stratified shell, and bring up thence not an ideal, but a real section of the planet's outer crust; this would not materially differ from such a section as geology has constructed, and which we represent above.

The facts of petrology, mineralogy, palæontology, &c., concur with what the more developed and higher-aiming sciences have warranted sound in theory so far as regards the explanation of geological dynamics. It may therefore be accepted as real and true (1) that each class or form of stratified deposits furnishes special petrological, mineralogical, geognostic, or fossiliferous characteristics; (2) that the same class or form of deposits exhibits these characteristics always and in all places; and (3) that these characteristics, as they rise from simplicity to complexity, supply the means of arranging in classified order the entire stratified surface of the globe into groups, systems, and formations which approximate to that of their natural arrangement and succession, and enable man to trace the history of the earth from the primary periods to the living present. We turn, therefore, now to explain these classifications of prehistoric stratifications.

Stratified rocks have been classified by these investigators, from their special point of view, into four great *groups*:—1, Primary or Palæozoic; 2, Secondary or Mesozoic; 3, Tertiary or Cainozoic; and 4, Quaternary, Post-tertiary, or (to adopt a designation used by Lyell) Neozoic, *i.e.* modern. Each of these groups has been subdivided and arranged into fairly well distinguishable formations: I. Primary into (1) Laurentian, (2) Cambrian, (3) Silurian, (4) Devonian (including the old red sandstone), (5) Carboniferous, and (6) Permian; II. Secondary into (1) Triassic, (2) Jurassic, (3) Wealden, or Cretaceous; III. Tertiary into (1) Eocene, (2) Oligocene, and (3) Pliocene; IV. Quaternary into (1) Pleistocene and Palæolithic, (2) Neolithic and Recent, *i.e.* including the present physical features and phenomena of the surface of the globe, as regards rock-structure, which fall more properly to be described and explained as a department of physical geography.

In the accompanying ideal section of the surface-shell of the globe the succession of the great epochs of geologic change is shown, and the range through which the igneous rocks are found extending their manifestations. It will help the student to realize the classification of rocks in the groups here noted, and to follow with readier apprehension our subsequent descriptive sketches of these eras and their phenomena. We have already, in Chaps. VI. and VII., treated of the Azoic group; and in Chaps. II. and V. have stated and described some of the principles and some of the appearances of stratification. In the present chapter we gather together, summarize, and collate these facts and their results, and so prepare the mind for taking an intelligent survey of the records of the earth's history in the geological succession, of which our section presents an epitomized specimen. An orderly exposition of this it will be our duty and delight to furnish. As a matter of course we have not here introduced specifically the rocks of the Quaternary or modern period, but merely indicate its existence as the theatre of some of the more striking phenomena of convulsion and change, a notice of which has engaged our attention in Chaps. III. and IV.

In all the explanations given of the changes indicated in the section before us an idea of orderly succession prevails; but in some the notion of *time*, and in others that of *cause*, predominates. In reality, however, there is no real antagonism between the results brought out by the disciples of these differing schools of thought; for causation operates in time, and as a matter of fact the phenomena of time (to whatever extent we may imagine it to stretch) can only be rightly interpreted by cause. Of course the first step to be taken, and the most important labour that can be undertaken in the earlier stages of research, are to obtain and put on record—as Werner, Smith, Cuvier, &c., did—the most exact knowledge attainable, in the most precise statement possible, of the phenomena of nature. When these observed phenomena are collected, collated, and described with accuracy, and in sufficient numbers, they can be classed in groups and may suggest some law which regulates, or some cause which either fully or approximately explains them. In many cases the phenomena are so singular and the imagination is so active that great risk is run of neglecting the rigorous rules of right reasoning, and giving way to undisciplined and hasty speculative explanations—vague, vast, and dreamy—

instead of carefully-framed examinations and still more cautiously-guarded reasoning—the fascinations of fancy are, at first sight, so much more attractive than the experimental trials of truth.

Because geology concerns itself with a series of systematically linked phenomena, evidently the result of natural agencies, though necessarily leading men's thoughts to physical causes acting under diverse circumstances, and bringing about results of a kind so much removed in their appearance to the casual beholder from those observable in what we call the ordinary every-day phenomena of our little life, it lends itself freely to differences of explanation. Just as history, though it recounts the occurrences and events of time and the institutions which have developed themselves in society, may be told as a mere narrative of incidents and accidents, or may be recounted as the elements and actual outcome of a continuous chain of development from thought to cause, from intent to accomplishment, so may geology be made a mass of striking detail and a description of singular facts and phenomena, or be, while giving ample information on the phenomena of rock-structure, educatively explanatory of the principles which underlie and cause the sequences of stratification. From what *is* it reaches back to what *has been*, and so, as it were, ideally re-lays the foundations of the earth, uprears the fabric of the telluric shell, traces the operation of air and water, frost and fire, observes the processes of chemical composition and decomposition, estimates the conflict between the static and dynamic offices of force, and makes experience of the present the exponent of the phenomena of the past.

The accumulation of facts presented to man's view in the book of nature requires to be reduced to system by science, and to be translated by thoroughly tested theory into truth. Geology takes as its guiding light experience. It accepts natural causes, as far as they can be followed in their operation and consequences, acting under similar or nearly similar conditions, as offering a basis for the interpretation of nature, *i.e.* as likely, in all past time, to have operated in a somewhat similar manner, and to have produced in like circumstances like effects as they do now. If there be (or may justly be thought to be) differences in identity of condition or intensity of activity, these must be allowed for and duly recognized, and only under the severest stress of logical necessity does it permit the introduction of strange causes or of abnormal suppositions. A true knowledge of nature, it assumes, will unfold itself to the straightforward student of nature when he conducts his investigations in the spirit and according to the principles of a thoroughgoing (and therefore trustworthy) inductive philosophy.

The following are some of the determined facts of geology, and the results deduced from them in the course of scientific inquiry:—1. That the rocks composing the earth's crust may be arranged in relation one to another, and may be classified in due order with some approximate correctness, not only as to their succession, but also with reference to their relative time. This relative age of strata is in great measure determinable by the fact that traces of organic life are contained in stratified rocks in the shape of fossils (Lat. *fossus*, dug up), *i.e.* mineralized relics of organized substances and existences, such as vegetables and animals, which have undergone change since they were entombed "before decay's effacing fingers" had destroyed their vital structure, or which have been preserved in casts or moulds set and hardened prior to their forms being destroyed or injured. The fossils found in each stratum are evidences of the forms of life prevalent during its deposition. Plants and animals are occasionally preserved entire, shells have been found in many localities unaltered, the bones of reptiles, the teeth of fish, and even the remains of mammals have been found in a state of partial or complete preservation. Often substances of organic origin have their material elements transformed, but their structure retained—like the silicified wood-opal of Antigua; while not unfrequently the casts of vegetables and animals are to be found completely filled with foreign matter, though the internal structure has entirely disappeared, as the shells found in the Cumberland district, entirely transformed into calamine or hæmatite. This branch of geological study has become so extended and important of late that it may almost be regarded as constituting a new science, called palæontology (Gr. *palaios*, antique; *onta*, beings; and *logos*, a discourse), which seeks, through the fossilized remains of organized bodies contained in the rock-structures of the earth, to form and set forth a history of the manifestations of life on the globe, and, by gathering precise particulars concerning all that is known of the signs of life in the past, to elucidate the stages through which animate nature has proceeded from the earliest appearance of living structures on the earth to those species and races which now hold possession of the globe.

2. That those strata in which organic remains occur—whether of plants or animals, zoophytes, shells of invertebrate or bones of vertebrate creatures, as the case may be —were originally deposited slowly and gradually as sediment resulting from the waste and denudation of the rocks of the Azoic groups, and that these layers or beds naturally took a nearly horizontal position. We know how water seeks its level, and how earthy matter, held mechanically suspended in it, precipitates itself as sediment, and how extraneous objects of size or weight sink and are surrounded with the sediment, among which they find a place. We know also, that if the earthy ingredients of the water are of the same character and composition, and the rate of deposition is continuous, there will be no observable stratification, *i.e.* differentiation of layer from layer; but that if matter be of one sort at one time, and of a different sort again, signs of stratification will be perceived in the mass. The sources of such sediment must have been numerous. Air decomposes friable materials, and wind sweeps the surfaces clean for new decompositions to take effect. Rains, in their fall and beat, erode the surfaces they impress, and as percolating runnels, springs, brooks, streams, or rivers, waste and wear away the looser materials over which they move, against which they press, or upon which they bear down with the accumulative force they acquire in their course. Frost exerts an immense mechanical power. Water gets into the minute invisible pores of rocks, their crevices and hollows, and between their masses; on freezing it expands, causes cracks and breakage, and acting like a wedge, effects cleavage and disruption; and when it thaws it carries away the disintegrated matter it has thus separated and dislodged. River-ice sometimes acts as a pushing force for stones and crumbled rocks, sometimes as a float for small stones, pebbles, and rubbish. Glaciers not only carry substances with them, but carve into *striæ*, scratches, and ruts, the courses along which the sand and fine clay produced by their grinding action are detached from the surfaces down which they glide. Icebergs, falling off from the fronts of glaciers at the coast, bear with them into the sea the accumulations the glaciers have made. Sometimes the ice-foot—a narrow belt of ice encircling an arctic coast—gets laden with debris, blocks, &c., and carries its cargo out into the sea-bottom. The sea is an ever-moving agent of disintegration. These and many other agencies act together to provide sedimentary matter for stratified deposition.

Many of the organic matters contained in these sediments —such as delicate shells and finely traceried coral-stems—are too tender and fragile to have borne any violence in their removal, and the way in which they lie embedded in the extremely fine sedimentary matter shows that the precipitation of the denuded matter must have been slow, gentle, and continuous. Of course there are some beds which, like the conglomerates, consist, not of fine particles, but of more or less rubbed and rounded stones, ground as they are by water-wear, which tell of their origin from hard rock, of their long process of polishing, and yet of their being brought together by strong currents, speedily compacted into beds in their matrix—silicious, calcareous, argillaceous, or ferruginous, as the case may be—by superincumbent pressure, pressure so great in some instances that the pebbles of the pudding-stone have been found penetrating each other.

3. The masses constituting the stratified portion of the earth is of immense depth or thickness, though undergoing many and material modifications in the character and pro-

portions of each deposit in different localities. Hence, though the entire mass of the stratified fossiliferous deposits has been estimated at 22,750 feet, or nearly $4\frac{1}{4}$ miles in thickness, the different deposits are not found everywhere of uniform depth, but are variable and uncertain. For instance, in Derbyshire the lower carboniferous limestone exhibits 750 feet of limestone, without admixture of sands or clays; in Tynedale the similar and contemporaneous strata are 1750 feet, of which, however, 1283 feet are sands and clays, and 367 feet are limestone: these approximations are rough. At Bath we have 480 feet of oolitic limestone, of which nearly a half is sand and clay, intermixed with calcareous matter, while at York its analogue is 750 feet, of which only about 2 feet is limestone. The carboniferous deposits (exclusive of old red sandstone) are estimated at 3000 feet in thickness, yet they afford phenomena like those of the Dalkeith coal-field, the surface of which the Esk traverses through faults of 100 to 500 feet, and the still more striking circumstance that while many of the seams at Newcastle—where the coal measures are about 2000 feet in thickness—are wrought under the sea, yet at Chipo, which rises out of the plain on which Santa Fé de Bogota stands, in South America, coal is found 8000 feet above the sea-level; and even above the snow-line, at Huanoco, in Peru, 12,800 feet above the level of the sea, coal is found.

4. The agencies by which the transport and deposition of the matter of these stratified rocks may be regarded as having been, in the main, very similar to those which we find at work around us, and probably did not differ very greatly, if at all, in the intensity of their operations; or, at least, it is safest to base opinion and calculations on what is known, until necessity compels the adoption of unfamiliar forces and forms.

5. That the periods at which stratified deposits were made were probably periods of depression of the bed of the ocean, either continuous or nearly continuous, during the operation of their specific stratification.

6. That these strata have been raised, dislocated, disturbed, and distorted into mountainous elevations; that cracks, wrinkles, and contractions have occasioned valleys, ravines, ocean-beds, and other hollows; that heated masses from beneath have shaken and even penetrated these stratified deposits, thrust themselves, by interpolation, into crevices formed by their disrupting force, and even ejected themselves through fissures in these strata and spread over their surface. But since their upheaval and elevation the rocks so formed have been carved and sculptured into hill and valley, river-course and lake-bed, &c., by water, ice, snow, and other forces of denudation.

7. That, so far as we know, the unstratified rocks of the telluric shell may be considered as matter which had formerly been in a state of fusion through heat, and which has subsequently been brought to a solidified state by gradual cooling down, and formed the original source of stratified matter.

These are the main conclusions at which geologists may be said to have arrived as the result of that wide and varied induction of known facts which they have collected and compared with the operation of known causes; and it is from the consilience of a thorough induction and of a careful deduction that geological science derives its power. Facts come to us always with the twofold force of things and thoughts—we know them only by the thoughts they elicit. Theory is consistent thought regarding clearly ascertained facts, and geology presents the facts of observation bound together by the clearest theory attainable regarding these facts, and progresses nearer to a trustworthy interpretation of the rocky volume of the earth's surface as fresh facts enable its cultivators to prove or correct their theories.

ALGEBRA.—CHAPTER VII.

SIMPLE EQUATIONS DEFINED AND EXEMPLIFIED—EXERCISES.

SPEAKING broadly, every numerical operation is an equation: $3+5+7=15$, $15-8=7$, $5\times3=15$, $15\div5=3$, and so on, are each equations of a very simple character. Even the more profound questions set before us in the compound rules, and in the complicated operations they involve, are in this general sense working out equations. An equation is an assertion of the equality of two magnitudes (of whatever sort) one with another—not a *proof* of the equality, but an *assertion* of it. It is typically exhibited as $A=B$, or $A=B+M$. Algebra is a language of symbols, in which the process of reasoning regarding magnitude is carried on more readily than in ordinary language. If, for instance, in ordinary arithmetic we are asked to divide the magnitude 100 into three portions in such a way that the first part should exceed the second part by 5, and the second part exceed the third part by 10, we should require to reason somewhat after this fashion:—(1) As the first part is to exceed the second part by 5, the second part must be equal to the first part made less by 5; (2) as the second part is to be greater than the third part by 10, the third part must be equal to the second part made less by 10, and therefore the third part must be equal to the first part made less by 15. The sum of the three magnitudes is equal to the *first* part increased by the first part made less by 5, and by the first part made less by 15; in other words, the total of these magnitudes is equal to three times the first part made less by 20, or three times the first part are equal to the sum of the three parts increased by 20. The sum of the three parts is 100; the sum of three times the first part is equal to 100 with 20 added, that is 120; and the first part must be equal to the third part of 120, *i.e.* 40. The second part is then $40-5=35$, and the third part is $40-15=25$, giving $40+35+25=100$. Algebra symbolizes this question thus: let x denote the *first* part; the *second* is then $x-5$, and the *third* $(x-5)-10$, or, when simplified, $x-15$; so that we have $x+x-5+x-15=3x-20$. By the conditions of the question $3x-20=100$, therefore $3x=100+20=120$; and it follows that (1) $x=40$, (2) $x-5=35$, and (3) $x-15=25$.

An algebraical equation is an expression which states the equality of two quantities, one of which, however, is usually an unknown quantity. A quantity is said to be *known* when its value is given in numbers, and *unknown* when its value is not given in numbers; thus $x=5$ may be said to be a known quantity, and $x-3=4$ is called an unknown quantity. The object of an equation is, from the known quantity to discover that which is unknown. This is done in the latter case by making $x-3=4$ into $x=4+3$, *i.e.* 7. For *known* quantities, numbers or the earlier letters of the alphabet, a, b, c, &c., are generally employed, while unknown quantities are represented by the final ones, as x, y, z. The parts of an equation on either side of the sign of equality are called its members or sides. That on the *left* is named the first, that on the *right* the second. Members are composed of one term, or more than one, as $2x+3=x+7$ is an equation of which $2x+3$ is the first and $x+7$ the second member. This may be resolved thus: $2x+3$; $2x=x+7-3$, therefore $x=4$. In this case the identity is not of *form* but of *value*, and the object of the equation is to secure the certainty of the complete identity of the form and the value, for we now see that $2x+3=8+3$, *i.e.* 11, and that $x+7=4+7$, *i.e.* again 11. Thus then we know that both in form and value $2x+3=x+7$ are transformable into the obvious equation $11=11$. A self-evident sameness is called an *identity*. An *equality* is said to be verified when an equation has been solved. To verify an equality is to show the correct value of the unknown quantity in a given equation, and to prove that it is so by substituting this value for the symbolized one in the question. The solving of an equation means the performing of the operations necessary to discover the value of any unknown quantity given (or that has arisen) in a question—*e.g.* In the equation $x-5=16-3+2$, when we say $x=16-3+2+5$ we find as a result that $x=20$, hence $20-5=15$; and also that $16-3+2=15$, *i.e.* $15=15$.

When an equation contains an unknown quantity (not actually identical or impossible) mixed with known quantities, the value of that unknown quantity is said to be *implicitly* expressed by the equation; that, in other words, the equation contains enough in it to enable the value of the unknown quantity to be determined, although it does not

exactly and directly inform us what that value is. When a previously unknown quantity is brought by any legitimate operation to stand alone on one side, and nothing else except known quantities stand on the other, the value of the unknown quantity is then said to be explicitly declared. For instance, if we have the equation $\frac{1}{2}x+\frac{1}{3}x=10$, we can transform that into $3x+2x=60$, and $5x=60$ and $x=12$, and then we have made explicit the value of x, which was only implicit in the question, and the equation is solved or resolved. Again, supposing the equation given to be $\frac{x}{6}-\frac{x}{4}-9=\frac{x}{3}-\frac{x}{2}$, on finding that the least common multiple is 12, we transform this into (1) $2x-3x-108=4x-6x$, (2) $x-108=2x$, and (3) $x=108$.

A simple equation is one which contains and is concerned with only the *first* power of the unknown quantity (or quantities). Equations may be either numerical or literal. The former contain only particular numbers and the unknown quantity, always expressed by a symbolic letter, as $5x-4=3x+6$; this yields (1) $5x=3x+6+4$, (2) $2x=10$, (3) $x=5$, and we can easily see that $5x-4=21$ and $3x+6=21$. The latter contains only literal data, *i.e.* quantities indicated by letters alone; as $ax+b=c$. If any unknown quantity found in one member of a question is transferred to the other side by any legitimate process, that process receives the name of transposition of terms; as $7x-30=6x-10$ becomes by transposition of terms $7x=6x+30-10$, and that becomes $x=20$.

An equation of condition is one which is true only for *certain values* of the symbolic letters. For instance, the equations $x+1=9$, and $y-4=6$, are true only on the condition that x is 8 and that y is 10. The individual quantities of the equation are called its terms.

An equation of condition, containing a letter the value of which is unknown, is solved when that number for which the unknown letter must stand is determined, and that particular number is said to satisfy the equation.

Where there is only one unknown quantity, it is usually denoted by x, and to effect a solution of the given equation is to find the number which x denotes. In the operation for that purpose we shall have occasion to make use of the following self-evident truths:—

I. If to two equal numbers we add the same number, the sums will be equal—*i.e.* if equals are added to equals the wholes are equal; as if $p=q$, then will $p+a=q+a$.

II. If from two equal numbers the same number be subtracted, the remainders will be equal—*i.e.* if equals be taken from equals the remainders are equal; as if $p=q$, then $p-a=q-a$.

To illustrate these axioms, let it be required to find the value of x which will satisfy the equation $4x-4=3x+3$. If we add 4 to each of these equal quantities, we get

$$4x-4+4=3x+3+4;\ \text{that is, } 4x=3x+7.$$

Subtract now $3x$ from both of these last, and the equation becomes

$$4x-3x=3x-3x+7;\ \text{that is, } x=7.$$

To prove that 7 is the true value of x, substitute that number for x in both sides of the given equation; if the numbers have the same numerical value, then must 7 be the true value of x. This process is called, as we have said, *verification*—as,

$$x=7,\ \text{then } 4x-4=4\times 7-4=24$$
$$\ldots\ldots\ 3x+3=3\times 7+3=24.$$

The two preceding axioms enable us to apply the rules of addition and subtraction in the solution of equations; the following two extend these rules to multiplication and division—namely,

I. If two equal numbers be multiplied by the same number, the products will be equal numbers; as

$$\text{If } p=q,\ \text{then is } mp=mq.$$

II. If two equal numbers be divided by the same number, the quotients will be equal numbers; as

$$\text{If } p=q,\ \text{then is } \frac{p}{m}=\frac{q}{m}.$$

From these principles it immediately follows that, *If both members of an equation be either both multiplied or both divided by the same quantity, the results will still be equal.*

To illustrate this, let it be required to find the value of x which will satisfy the following equation, $12x-23=7+2x$. Adding 23 to each side of the equation, and reducing, we get $12x=30+2x$. Subtracting $2x$, and reducing, this last becomes $10x=30$. Now, if we divide both these equal quantities by 10, the coefficient of x, we find $x=3$. Here follows the process of *verification.* If $x=3$, then (1) $12x-23=13$, and (2) $7+2x=13$.

In the actual solution of equations we do not formally apply the foregoing axioms, but use the abridged principle as expressed in the following proposition:—Any term of an equation may be removed from one member and placed in the other with a contrary sign. This is nothing more than a convenient mode of applying the principle just expressed, by saying that two equal quantities are still equal when equally increased or diminished; for,

$$\begin{array}{ll} \text{Let} & ax-\ b=cx+d; \\ \text{Add } b,\ \text{then} & ax=cx+d+b; \\ \text{Sub. } cx,\ \text{then} & ax-cx=d+b, \end{array}$$

in which the terms cx and b are upon different sides with opposite signs, and might have been so placed at once by application of the proposition.

This is the law of what we have called *transposition.* The following are instances of its practical application:—

Given Equations.	Obtained by transposition.	Value of x.
$3x+9=2x+12$	$3x-2x=12-9$	$x=3$
$7x-8=6x-2$	$7x-6x=8-2$	$x=6$
$20-3x=22-4x$	$4x-3x=22-20$	$x=2$

By means of the axioms relating to multiplication and division we are able to transform an equation which contains fractions into one having all its terms expressed in an integral form.

$$\text{Let } \frac{1}{2}x+\frac{1}{3}x=\frac{3}{4}x+\frac{5}{8}.$$

Multiply every term of this equation by a common multiple of the denominator of the fractions—that is, by $3\times 8=24$ (for the 2 and 4 are manifestly included in 8)—then we get

$$12x+8x=18x+15,$$

whence it follows that $x=7\frac{1}{2}$.

The operation of reducing an equation containing fractional terms to an integral form may then, it appears, be performed by multiplying both numbers by any common multiple of all the denominators; and generally the least common multiple is the most convenient.

When the term "equation" is used without any qualification it is always to be understood to signify an equation of condition. There are, however, various classes of equations of condition; those which contain only the first power of the unknown quantity are said to be of the *first degree*, and are called *simple equations.* All the equations which have hitherto engaged our attention pertain to this class, and have only one value of the unknown quantity; whereas those equations in which higher powers of the unknown quantity are found, are satisfied by more than one value. For instance, the equation

$$3x-5=2x+2,$$

is true only when x is 7; but the equation

$$2xx+3=7x,$$

is true when $x=3$, and also when $x=\frac{1}{2}$, but in no other case.

The difficulty of solving equations depends upon the degrees of the equation and the number of the unknown quantities; we shall take the cases in the order of their difficulty, premising that equations of the first and second degrees are of most frequent occurrence in the practical applications of algebra.

EXERCISES.

1. $3(x-2)+4=4(3-x)$. *Ans.* $x=2$.
2. $6(x+3)+4x=58$. " $x=4$.
3. $4(3+2x)-2(6-2x)=60$. " $x=5$.
4. $6(4-x)-4(6-2x)-12=0$. " $x=6$.

5. $5(x+4)-3(x-5)=49$. *Ans.* $x=7$.
6. $7(x+1)=3(4+2x)$. " $x=5$.
7. $5x-1=2(1+x)+3$. " $x=2$.
8. $7(1+2x)+2=3(4x+2)+9$. " $x=3$.
9. $4x+2=2(x+6)=4$. " $x=3$.
10. $5(x+3)=21-x$. " $x=1$.
11. $3(x-1)-x=9$. " $x=6$.
12. $4x-2a=3x+2b$. " $x=2(a+b)$.
13. $7+6x-4=12+3x$. " $x=3$.
14. $4(x-2)=10x-38$. " $x=5$.

ASTRONOMY.—CHAPTER IX.

THE YEAR, TROPICAL AND SIDEREAL—PRECESSION OF THE EQUINOXES—NUTATION—PERTURBATION OF THE PLANETS—KEPLER'S LAWS OF PLANETARY MOTION—TRANSIT OF VENUS.

THE rotation of the earth on its axis and its revolution round the sun give rise, the first to the day, and the second to the year. But as there are the sidereal day, governed by the stars, and the solar day, regulated by the sun, so there are two years, the *tropical year* and the *sidereal year.*

The tropical year is the period which elapses between two successive passages of the earth's centre to the same equinox or point where the ecliptic cuts the celestial equator, the length of which (expressed in mean days) is 365·242264 days. If, however, instead of thus measuring the year, we take the time which the earth requires to return to the point of its orbit in which the sun appears to coincide with the same point or star of the heavens, that period of time is the sidereal year, the duration of which is 365·2563835 days. The sidereal year is therefore longer than the tropical year by 20 min. 24·95 sec. of time, and this shows that the equinoctial point has fallen back, so that the earth arrives earlier at this point than it would have done if it had remained immovable; this phenomenon is termed the *precession of the equinoxes*, because its appearance is as if the equinox *goes forward* to meet the sun. The result of this movement is, that when the earth occupies the same position in its orbit year by year, the sun arrives at the equinoxes sooner than it otherwise would, owing to the retrograde motion of these from *east to west.* The annual amount of this motion is, however, exceedingly small, and to say that the equinox falls back or retrogrades is the same as saying that the *plane of the equator has varied in position*, and as the earth's axis is always perpendicular to this plane, it follows that it has not remained parallel to its previous direction; indeed, it varies in direction (still preserving the same angle with the ecliptic) in such a way as to describe an entire cone in an interval of 25,817 years; and at the end of this period the equinoctial points will have made a complete revolution of the heavens. The earth's axis, in executing this slow movement, describes a complete circle on the surface of the heavens, and the celestial poles are therefore incessantly shifting, so that the northern pole, now quite near the Pole-star, is still approaching it, and will continue to do so until the year 2120, when it will be within half a degree; it will then recede from the present Pole-star (α Ursæ Minoris), and in 12,000 years the brilliant star α Lyræ, of the first magnitude, which is now 51° 20′ from the pole, will be within 5 degrees of the polar point, and Canopus, in the southern sky, will be found in the vicinity of the other pole.

The earth's axis also performs another movement simultaneously with that just described, but in a much shorter period, 18½ years. The conical motion of the earth's axis, which produces the precession of the equinoxes in 25,817 years, changes progressively the direction of its axis, without altering its inclination to the plane of the ecliptic. This inclination, however, does vary on account of the other movement, which causes the axis to oscillate during each period of 18½ years in a circle round the mean position it would occupy were it only influenced by the movement of precession. This second movement is called the *nutation* or "nodding" of the earth's axis, and it gives rise to slight changes, sometimes greater, sometimes less, in the obliquity of the ecliptic to the celestial equator. All these movements of rotation and revolution round the sun, and those of precession and nutation, are effected simultaneously by the earth. The earth's motions of precession and nutation are the result of the law of universal gravitation. Were the earth a true sphere the direction of its axis of rotation would always preserve its parallelism, and the action of gravity of the other planetary bodies would not change this direction, as the terrestrial poles occupy an invariable position on the globe. The earth, however, is not a sphere, but is swollen at the equator. It is like a perfect sphere covered with an envelope or padding, the thickness of which decreases from the equator to the poles, at which the thickness is nothing. The action of the mass of the sun on this padding on the sphere of the earth is the cause of the continuous retrograde movement of the equinoctial points, and in like manner the action of the mass of the moon on the increased mass of the earth's equatorial diameter produces an analogous, but much more rapid motion, the nutation of the earth's axis. In consequence of the above-described motion of the equinoctial points the *signs* of the ecliptic do not correspond at present to the *constellations* which bear the same names, but lie about one sign or 30 degrees westward of them. Thus that division of the ecliptic which is called the sign Taurus lies in the constellation Aries, and the sign Gemini in the constellation Taurus. Undoubtedly when the ecliptic was first divided and the divisions named, the several constellations lay in the divisions which bear their names.

The movements of the earth in space are also subject to the attractions of the masses of the other planets. As all these actions are reciprocal—the attraction of gravitation acting on the masses of all the planets by the attraction each exercises on the other—it is sufficient to point out its extreme importance. As the masses of the other planets act on the earth, each following the general law, there is always an attractive force tending to disturb the earth's

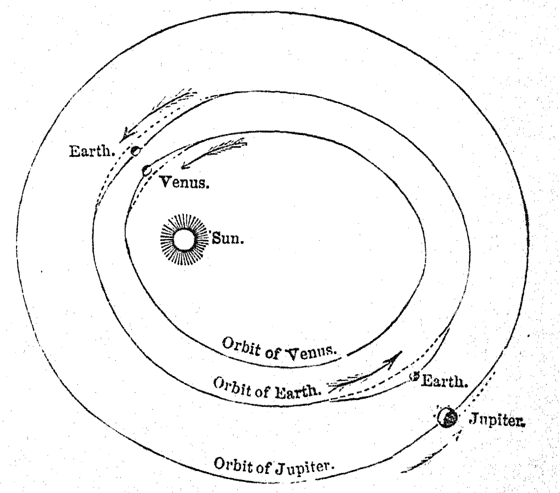


Diagram showing the mutual attractions of the Planets.

orbital motion more or less according to the positions of the disturbing masses which periodically alter its movements. The inclination, the direction of the major axis, the eccentricity of the orbit, are elements which are all affected, changing at once the position and form of the orbit of the planet. These attractions (arising from the law of gravitation) are named *planetary perturbations.* It was by observation of the perturbations upon the orbit of Uranus that the existence of the planet Neptune was foretold; and that the existence of the inter-Mercurial planet Vulcan is considered almost certain, arises likewise from observations on the perturbations of the orbit of Mercury. The diagram shows, in a somewhat exaggerated form, the perturbations of the orbits of the earth, Venus, and Jupiter, arising from the attraction of their respective masses upon each other during their orbital revolutions round the sun.

The laws which govern the motions of all the planets, as enunciated by Kepler, demand a few words, so as to render

clear the secondary phenomena which result from these fundamental laws, such as the tides and planetary perturbations above described. It was Copernicus who first laid the foundations of modern astronomy by his discovery of the movement of the earth and planets round the sun. But the real form of the earth's orbit, and those of the other planets and their velocities, remained undetermined for some time. It was by Kepler, who discovered three laws, that these different problems were finally solved.

A planet revolving round the sun describes a continuous curved line, each point of which lies in an imaginary plane which passes through the centre of the sun. Such an orbit is termed a plane curve. The form of this curve is determined by Kepler's first law, which states that the orbit of each planet is an *ellipse*. Now, an ellipse is a curve in the form of an oval, and its nature will be best understood by drawing such a curve, which is readily accomplished by taking a thread the two ends of which are attached to two pins fixed into a sheet of paper or a board; the thread is to be longer than the distance between the two fixed points. If the thread is then kept stretched by a pencil in such a manner that the point of the pencil can traverse the paper, and if the pencil is moved along the thread, a curve will be traced which can be completed by placing the thread and the pencil on the other side of the line which joins the fixed points; the curve so traced is an *ellipse*, the two points to which the thread is affixed are termed the *foci*, and the two portions of thread which connect these foci with each point of the ellipse are the *radii vectores;* as the length of the thread remains constant, the *sum* of the *radii vectores* is the same for all points of the ellipse. This property is the definition of an ellipse. The line drawn through the two foci is the *major axis* of the ellipse, and the middle point of the major axis is the centre of the ellipse. If with the same foci shorter thread is used, the figure of the ellipse will become more elongated; and if threads of greater length are employed, the ellipse will gradually approach the form of a circle, but never absolutely reach the circular form. If, with the same length of thread, the distance between the foci is increased or diminished, the same difference of curve will be obtained; the length of the major axis remains constant, but the more the foci are separated the more oval the form of the curve.

Kepler's first law is, that *each planet describes round the sun an orbit in the form of an ellipse, and the centre of the sun is always one of the foci.* It therefore follows that the distance of a planet from the sun varies continually during its revolution.

Kepler's second law states that the movement of a planet is by so much the more rapid as the planet approaches the sun, and this second law determines the velocity. If a planet is taken in twelve positions in its orbit during the successive months of the year, and the arcs described by the planet in

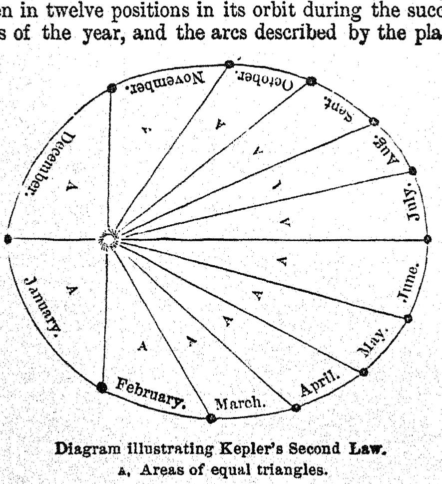


Diagram illustrating Kepler's Second Law.
A. Areas of equal triangles.

equal times are marked off by *radii vectores*, it will easily be understood that the paths described in equal times are of unequal length. But the triangles thus formed have as bases arcs described in equal times, and their areas are found to be equal. Therefore, if the length of time be doubled, tripled, &c., the areas of the triangles will be doubled, tripled, &c. Kepler's second law is therefore—*The areas described or passed over by the radius vector of a planet from the solar focus are proportionate to the time taken in describing them.* This second law therefore clearly demonstrates that the arcs described in equal times are smaller as the planet recedes from the sun, and become greater as the planet approaches the sun—that is, that what the triangles lose in length they gain in breadth, their areas remaining constant. The planet therefore moves faster the nearer it approaches the sun.

The first two laws of Kepler deal with each planet considered by itself, and would mathematically hold good were there only two bodies, the sun and a planet. Kepler's third law establishes a relationship between every planet in the solar system. It has already been pointed out that the mean distance of the various planets from the sun continually increases from Mercury to Neptune, and the same also holds good for their orbits round the sun. Kepler's third law establishes the relationship that exists between the periods of revolution and the major axis of the orbits. Thus, the periods of the revolution of the principal planets are given in the table below in mean days, and likewise double their distances from the sun in thousandths of double the mean distance of the earth:—

	Periods of Revolution. Days.		Double Mean Distances from the Sun, or Major Axis.
Mercury, ...	87·97	...	387·1
Venus, ...	224·70	...	723·3
The Earth, . . .	365·26	...	1000·0
Mars, ...	686·98	...	1523·7
Jupiter, ...	4332·58	...	5202·8
Saturn, ...	10759·22	...	9538·8
Uranus, ...	30686·82	...	19182·7
Neptune, ...	60126·72	...	30040·0

If the periods of revolution are now multiplied by themselves, then the *square* of the period of the revolution of the planets will be obtained. If, again, the number which denotes the major axis of the orbit be multiplied by itself three times (or raised to the third power), the products will be the *cubes* of the major axis. If, then, two squares in the first column and the two corresponding cubes in the second column are compared, and one square divided by the other, and also one cube by the other, when the quotients are compared they will be found equal. For example, take Venus and Jupiter. The square of the times of revolution are for Jupiter 18771249·4564, and for Venus 50490·0900. The cubes of the major axis are for Jupiter 140,835,258,325, and for Venus 378,391,648. Divide one square by the other, the quotient is 372. Divide one cube by the other, the quotient is also 372.

Kepler's third law is therefore—*The squares of the times of revolution of the planets round the sun are proportional to the cubes of the major axis.* Thus, the time of the revolution of the planets being known, their major axis may be calculated, and their mean distances from the sun determined, and knowing the absolute value of one, the absolute value of all can be calculated.

Suppose, for example, that we wish to find the distance of Jupiter. We can easily determine from observation what is Jupiter's periodical time by noticing how long it takes after leaving a certain point in the heavens to come round to the same point again. Suppose this period (for the sake of simplicity) to be twelve years, the earth's period being one year. The earth's mean distance from the sun is known to be about 91,308,642 miles. Now we have here three terms of a proportion of which the fourth is required, therefore the solution is a simple case of the rule of three.

Thus:—The square of 1 year : square of 12 years : : cube of 91,308,642 : cube of Jupiter's distance. The first three terms being known, we have only to multiply together the second and third and divide by the first to obtain the fourth term, which gives us the cube of Jupiter's distance from the sun, and by extracting the cube root we obtain the distance itself.

So truly is this a law of the solar system, that it holds good of the new planets which have been discovered since Kepler's time as well as in the case of those known to him. Hence it is justly regarded as one of the most interesting and important principles yet developed in astronomy.

It will be observed that in the above supposed calculation the earth's mean distance from the sun is used as our standard measure or starting point in calculating the distances of all the other planets.

The distance of the earth from the sun is universally recognized as the standard unit of astronomical measurement, and the greatest importance is attached to the accuracy of the means employed in its determination. This unit at once lays down the scale upon which the entire solar system is constructed.

Several distinct methods are employed to solve this problem. The one, however, most universally relied on depends upon the observation of the phenomenon termed the *transit of Venus*, and the value of the sun's distance at present received has been deduced from these transits by a method due to the astronomer Halley.

When Venus in passing between the earth and the sun crosses the sun's disc it appears as a small round black spot (Plate IV., fig. 7). If two observers are placed at two different stations, properly selected on the earth's surface, A in the northern hemisphere and B in the southern one, when Venus, V, is exactly between the sun and the earth, the observer at A will see her projected on the sun's disc at a certain point, say V_2, while the southern observer at B will see the planet projected higher on the disc, at a point say V_1. Now the angle which it is necessary to measure in order to determine the sun's distance is $A\,V_1B$, and as the proportion of the measured angle $V_2A\,V_1$ to the desired angle $A\,V_1B$ is as V_1V to $A\,V$, or very nearly as 72 : 78, everything depends upon finding correctly the value of the angle $V_2A\,V_1$. When the distance between the two stations A and B is sufficiently extended, the planet will not appear to enter on the sun's disc at absolutely the same moment at the two stations, and therefore the paths or the chords traversed will be different, that is, of unequal length ; consequently the time of transit at one station will differ from the time of transit at the other. This difference permits the determination of the difference in the length of the chords described by the planet, their respective positions on the solar disc, and the amount of their separation. This separation is the angle $V_1A\,V_2$ required; having the value of this, the value of $A\,V_1B$ can be calculated, and from it the sun's distance determined. Were the stations A B situated at the extremities of a diameter of the earth, then the angle which it would subtend at the sun would be known, which, in other words, would be the sun's parallax.

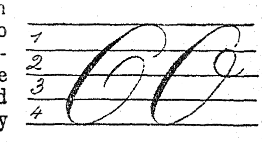
So far the earth's motion of rotation has not been taken into account, but its motion modifies the result, and renders it necessary to observe the transit from certain parts of the earth's surface. The instant and place at which the planet will enter and leave the solar disc are accurately known by astronomical calculation, and also the exact situation of the earth at the moments of ingress and egress. If, therefore, two planes are supposed drawn from the centre of the earth tangential to those parts of the sun's limb at which the planet enters and leaves the solar disc, it will be evident that some parts of the earth will see the planet enter the disc sooner than others, and some parts will see it leave the disc later, or according to the position of the place of observation, both ingress and egress will be accelerated or retarded, as the case may be. Therefore, by selecting one place of observation where both the ingress will be accelerated and the egress retarded, and another where the ingress is retarded and the egress accelerated, the greatest difference in the length of the chord or duration of the transit will be obtained. In the transit of Venus of 1882 these results were best obtained by selecting as observing stations, one on the seaboard of the United States of America, and the other near Repulse Bay, on the Antarctic continent.

PENMANSHIP.—CHAPTER VIII.

FLOWING GRACE-LINE CAPITALS—ANALYSIS OF, AND EXERCISES UPON THEIR FORMS.

Few qualifications in penmanship are so valuable as to be able to write a fair round hand—at once free and flowing, open and plain, comely and legible. Not, like Giotto's O, geometrically perfect in its circularity, but graphically round in sweeping ovalness. The type of a caligraphic round letter is an O which is in form an oval or ellipse. It consists of four circular arcs so joined together as to leave no angular outjuttings at their junctions and no appearance of rapid change of curvature. It should be smoothly, evenly, gradually, and pleasingly proportioned in its circularity. Being a purely curved letter, no part of it is a straight line, and yet its curvature is not entirely circular, because that would give the letter a look of constrainedness which is not desirable in actual writing. Although writing-masters often rigorously and persistently enforce the practice of the circular form in its most accurately geometrical proportions, it is not because it is to be exhibited in holograph penmanship, but as a gymnastic against that angularity and sharpness of turns to which the hand, especially of the careless, is constantly prone. Such angularity not only disfigures writing, but tends to make it, if not illegible, yet difficult to make out. The most accurate outline of a graphic O may be seen in a transverse section of an egg, *i.e.* an egg cut down the middle lengthwise, and regarding the shell as the ellipsoidal outline required.

On referring to the second last line of Plate II. the learner will see the capital O. It forms a simple, elementary, single-lined curved character. Its parts may be best observed by considering the whole length of the letter divided into four parts, such as is indicated on the margin. The upper curve in space 1, carried from right to left, is wholly a hair-stroke arc. On reaching the second space, by gentle pressure on the pen, gradually increased till space 3 is touched, and then as gradually decreased till the fourth space is arrived at, the curved down-stroke is broadened throughout two spaces. It then, on space 4, forms a hair-stroke curve exactly the reverse of that formed on space 1, passing from left to right. On spaces 3 and 2 the hair-stroke is continued in a curve on the right, the reverse of that on the left, and just as it reaches space 1, nearly opposite to the hair-stroke with which the letter was commenced, the upward stroke is swept round in a smaller curve lengthwise through spaces 2 and 3. This line may then be taken across the body of the letter to join the next letter in the word to be written. Sometimes, however, when it is intended to link the capital to a long letter, *l*, *h*, &c., this curve is transformed into a rounded loop and taken across the right-hand upward curve at the lower part of space 2. Though, while described analytically, it has been considered in spaces, the outline itself is not to be formed in parts. The mind is intended to see and note these peculiarities, and having fixed them in thought as guiding directions, to use them as rules to be observed while engaged in the early efforts made to complete the oval sweep with an entire and uninterrupted stroke of the pen. Great pains ought to be taken to acquire a fluent facility in forming this type-letter, not for its intrinsic beauty alone, but because the mastery of hand acquired in studying it imparts a power of giving graceful roundedness to all other curving lines occurring in written characters. The most difficult being accomplished well, all others become easy.

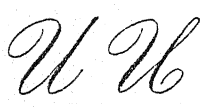


This will be at once perceived when we pass on to the letter C. Here we have a gently curved line taking its rise in mid-distance, on the lower part of space 2, and sweeping up to the top of space 1. From this point, till it reaches the upper part of space 3 on the right, the whole line is a precise counterpart of the portion of the letter O on the left. The terminal curve, though made lower down, is exactly the same as that in O. The letter C is not easily made graceful, and unless all the parts are nicely balanced and the

down-curve carefully graded in the thickening of its line, it can scarcely be made pleasing to the eye. It is, however, much employed, and therefore requires an extra amount of attention and care. This will be all the more apparent when we recall what has already been remarked, that the letter C forms the latter half of H, and notice, as we shall do immediately, that it constitutes also the upper half of G.

The tracing of these analogous parts of letters is not a mere matter of idle curiosity or of trivial remark. It serves to show us that in penmanship, as in everything else, one achievement gained aids in the achievement of another; and hence, not only encourages painstaking effort with the one, but minimizes, or at least economizes, the work to be done in accomplishing the other. For instance, on looking at G, we see at once that its upper part is really a reproduction of C, except that the terminal curve is not formed in it, because it requires to have another element added to it. This additional form is, in reality, the same as the letter *j* in the small-hand characters or the lower half of the capital J. The simple union of these two forms—capital C and small-hand *j* or the lower portion of capital J—constitutes G.

The similarity of the first parts of Q, U, and Y is apparent at once when they are brought into juxtaposition, as they are in Plate II. They each commence with an inverted oval. The convolution of the scroll in each is begun with a curving down-slope, proceeding from right to left, and then whirling upwards over itself, ready to be joined to the subsequent elements. In Q the part attached to the convolved oval is that of the latter part of L, viz. a down-sloping grace-line forming a loop, with a horizontal grace-line brought across it at the bottom. One might almost say that the commencing ovalesque arch of P, B, and R, added to the closing elements of L, constitute Q. To the scroll with which Q commences U adds the forms of *il* in small-hand characters, and is exceeding simple in its form. Sometimes, when greater elegance is sought, instead of adding the form of *l*, the form of a capital C is added, and when carefully managed it does impart greater attraction to the letter. The primary element in Y is similar to that of U, and the latter part may be most easily described as formed by the addition of *ij* to the convoluted scroll of U. The three last letters are rather difficult to analyze. In X the commencing scroll resembles that of Q, proceeds as the lower part of a grace-line, terminating in an ovalesque curve. This forms the first half. The second consists of three-fourths of the letter O, attached in the centre of the curve to the previous half. A not unfrequent form of X is made by commencing with the convoluted scroll of U, and adding the elements of H brought into union in the centre.



A very elegant, though somewhat complex, form is that presented by the letter E. It commences with a curved slope, proceeding from left to right, which shades off and merges into three-fourths of an O-form towards the left, and this, when it reaches the lowest point, loops round on itself and forms thereafter a somewhat rotund O, two-thirds of the size of that capital.

Kent in "King Lear"—following the opinion of Shakespeare's contemporary Richard Mulcaster, master of St. Paul's School, London—apostrophizes Z as "thou unnecessary letter." It is indeed somewhat superfluous, as it very seldom occurs, especially as a capital. It must, however, have a representative, and that given on Plate II. is probably as plain and elegant as any of the differing forms given to it. Very frequently it is made exactly like the small character *z*, and is simply three zigzagged lines. The forms chosen in our "flowing grace-line capitals" begins with a slightly curved sloping line, looping round itself towards the left and extended towards the right a little, in a horizontal direction, after the loop is formed; next, almost at a right angle, it gives down a straight sloping hair-line, which makes a longish loop over itself, rising about one-third of the length of the sloping line, and so sweeping thence as to form an inverted C; or it may be more easily understood if we say that when the loop turn is made at the base of the slanting hair-stroke, a nearly semicircular stroke is made, and to this is attached the lower loop-element of *j*, *y*, or *g*.

We have thus explained analytically and descriptively the "flowing grace-line capitals" as they are arranged upon Plate II., in which they are assorted in order from simple to complex, and so nearly approaching each other in likeness as to aid not only the eye in perceiving, but the hand in achieving, the difference in form which characterizes each. The student will act wisely who reads over these descriptive directions, comparing what is said with what is seen, and making sure that he has caught the idea of the form of the letters, not in part only, but as a whole. He may then, if he chooses, practise the elements of the letters part by part, separately and in succession. He should, however, always take care to bring all the parts together into oneness of form—smooth, clean, flowing, gliding part into part without sign of joining or interruption of sweep. Our endeavour has been to simplify the several steps so as to secure systematic progress, not as an imitative art merely, but also as an intellectual training in observation and in execution. We have sought to direct the mind which is to direct the hand, and to place before mind, eye, and hand, in the easiest succession, the several characters of the script alphabet. The student will find himself now able to carry on a systematic training which shall result in effective penmanship. We recommend as an exercise on the capital letters just studied the following series of words, so grouped as to introduce these letters, for the present, in their companionship of similarity. The capitals given in the type are to appear also in the script done in the exercise:—

Paul's Black Robe is fine.
Show Loyalty, Dutifulness, Humility, Kindness, and Justice.
A New Master Values Worth.
On Curious Grounds Quarter is Usually Yielded.
Xebecs excite Zealous care.
A.M.; L.S.D.; Y.F.I.; Cwts. Qrs. Lbs.; M.R.P.; Y.W.C.G., D.D.; LL.D.; D.C.L.: B.C.; A.D.; Q.R.S.P., &c.

NATURAL PHILOSOPHY.—CHAPTER XVII.

HEAT.

MODERN THEORY OF HEAT—TEMPERATURE, MEASUREMENT OF—THERMOMETERS—THE TEMPERATURE OF STEAM—THE BOILING POINT OF WATER—THERMOMETER SCALES—THE THERMOMETRICAL CORRECTIONS—LIMITS OF MERCURIAL THERMOMETERS—AIR THERMOMETERS—ALCOHOL THERMOMETERS—DIFFERENTIAL THERMOMETERS—MAXIMUM AND MINIMUM THERMOMETERS—BREGUET'S METALLIC THERMOMETER—PYROMETERS—SPECIFIC HEAT—CALORIMETRICAL CORRECTIONS—CALORIMETERS—THE SPECIFIC HEAT OF LIQUIDS, BODIES, AND GASES—INFLUENCE OF SPECIFIC HEAT ON CLIMATIC TEMPERATURE—LATENT HEAT OF LIQUIDS, STEAM, AND VAPOURS—MECHANICAL VALUE OF LATENT HEAT—THE LAW OF CHARLES AND ITS APPLICATION.

In studying the phenomena of nature we are, in the present state of our knowledge, forced to suppose the existence of *two distinct forms of matter*, the one *ponderable* or possessed of weight, which is capable of being observed under three conditions—namely, the solid, the liquid, and the gaseous states; the other *imponderable*, without appreciable weight, and possessing a mobility and subtleness of inconceivable extent, and by the agency of which the phenomena of heat, light, and possibly electricity are produced. Ponderable matter is distributed in space in various forms, and often at immense distances, as exemplified in the case of the stars. The other form of matter, generally called the *ether*, is supposed to fill all space, including the spaces which separate the molecules of ponderable matter from one another, and to pervade the vast expanse of the heavens. Until comparatively recent times heat, light, and electricity have been regarded as the effects produced by different forms of imponderable matter; but more recent investigations, and the progress made in scientific research, lead to the conclusion that the various

phenomena presented by each are probably due to the vibratory movements excited in one and the same imponderable fluid, the *ether*.

This may be taken, indeed, as the working hypothesis now, to the exclusion of any other; and philosophers universally regard heat (as they do sound, light, and electricity) as a *mode of molecular vibration*. Heat is transmitted, according to these views, by vibrations of the imponderable fluid called ether. Sound is transmitted by the vibrations of matter, as air, water, wood, metals, &c.; but heat and its congeners need no such coarse medium. What ether is we know not, nor even if there be ether, but we postulate it merely as the wherewithal to construct the waves of vibration, which waves we may almost confidently assert really do exist.

This mode of molecular vibration may be thus imagined. If we suppose the molecules of a body to be in a certain state of tension, then it is evident that when these molecules are set into vibration by added heat, which we assume to be simply added vibration, the body will expand and will be likely to pass from the solid to the liquid, and from the liquid to the gaseous form. Further, such vibrations will be readily communicable to adjacent bodies or to the circumambient ether. But all bodies have at any given time a certain measure of heat. There is no true *zero* of heat; but Fahrenheit's *zero* is now absurdly warm compared with easily producible amounts of cold (not known in his day), and the *zero* of the centigrade scale of Celsius' thermometer only pretends to be a convenient starting-point for measuring heat; it is simply the temperature of melting ice, and does not at all assume to be the beginning of heat. Are we then to say, in face of this, that all bodies at all times are in a state of vibration?—not that an addition of heat sets the molecules in vibration, but rather that it increases the vibration of the already vibrating molecules? Yes, that is indeed the fact that modern physicists firmly believe. We are taught to regard *solid* bodies as made up of molecules vibrating each of them round a certain fixed position, the exact form of that vibration being quite undetermined as yet, possibly indeterminable. Increase of heat would mean that the excursus of each molecule was greater in each vibration; decrease of heat would mean a lessening of the excursus made during each vibration. In *liquids* the state of vibration is so far altered as that the molecules have no fixed position, but easily move upon one another, and readily separate at the bidding of external force. But in *gases* the vibration of the molecules is so great that even at the lowest temperature consistent with the gaseous form they tend to drive one another apart and fly asunder in straight lines in all directions, pressing upon the walls of any vessel that may contain them. The effect of heat upon a gas is to increase the elastic pressure so exercised to a very great degree. Gaseous bodies may be regarded as perfectly elastic, that is, as occupying any certain space only under some definite pressure, however small.

From this view of heat it follows that it may at once be produced by anything which changes the motion of a body into the motion of its particles; hence friction, hammering, percussion, sudden condensation, chemical combination, and electrical discharges are all proper to produce, or rather to develop heat. For, taking the case of friction, here we have motion checked, as with a skidded wheel. The motion of revolution is still potentially there, but it is shown in the motion, or vibration, or tremor of the particles of the wheel —that is, the heat of friction—instead of in the motion of the wheel as a whole.

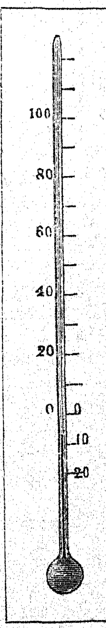
In examining the phenomena of heat the effects produced will be considered rather in their actual experimental results than as those resulting from any particular theory regarding the origin of heat. Facts are the foundations of the sciences; the theories concerning the essential nature of heat form merely a superstructure not essential to its existence. Philosophers may differ in their theoretical conceptions, but all agree upon the fundamental facts.

The distinction between hot bodies and cold ones is associated with the difference of the sensations experienced in touching various substances, according as they are hot or cold. The *temperature* of a body may therefore be defined to be its state with respect to sensible heat. When the amount of sensible heat in a body increases, its temperature is said to *rise*; and when this diminishes its temperature is said to *fall*; the term *hot* therefore indicates a high temperature, and *cold* a low temperature. The word *temperature* is therefore a general term, and applies to an indefinite number of intermediate temperatures between cold and hot. The temperature of a body is, therefore, a *quantity*, which indicates how hot or how cold it is. Thus, when it is said that the temperature of one body is higher or lower than that of another, it not only means that the one body is hotter or colder than the other, but also that the state of both bodies is compared with a certain scale of temperature *measuring* their relative heat and cold.

MEASUREMENT OF TEMPERATURE.

As the sensations of the human body depend upon too many variable conditions for scientific purposes, it is absolutely necessary to estimate the state of bodies from their observed action on some apparatus whose conditions are more stable than those of our senses. The properties of most substances vary when their temperature changes. With some these variations are abrupt, and indicate particular temperatures which may be taken as points of reference; others are continuous and serve as measures of other temperatures by comparison with the temperatures of reference. Thus ice is found to melt at a certain fixed temperature under ordinary circumstances. The temperature of steam which issues from boiling water is also constant when the pressure is constant. The melting of ice and the boiling of water furnish therefore two temperatures as points of reference widely apart. In order to measure temperatures in general some substance must be employed which has the property of altering continuously with the temperature. Of all available liquids mercury affords the largest range of regular expansion and contraction on both sides of ordinary temperatures. It becomes solid only when subjected to the lowest temperature of arctic winter, and boils at above the melting point of lead. It is also necessary that the material employed for measuring heat should rapidly respond to its influence. Mercury being a good conductor heat travels readily through it, so that its temperature is raised at a moderate expenditure of heat force. The amount of heat required to raise a given quantity of mercury one degree, is but half of that required for equally raising the temperature of the same volume of water, although mercury is thirteen and a half times denser than water.

Fig. 1.



The expansions of different substances under the influence of heat are not in general in the same proportion. Thus mercury and glass both expand when heated; but the expansion of mercury is greater than that of glass, so that if a cold glass vessel be filled with mercury, and both are equally heated, the glass vessel will expand, but the mercury will expand so much more that the glass will no longer contain it. If the glass be provided with a long tube the mercury forced out of the vessel by the expansion will rise in the tube, and if the tube is narrow and regularly graduated the amount of mercury forced out of the vessel may be accurately measured. The ordinary *mercurial thermometer* is constructed on this principle. The *bulb* is a cistern of comparatively large sectional area (fig. 1). When filled at a low temperature its overflow, produced by a rise of temperature, is forced up into the very narrow bore of the *stem*, the small capacity of which stretches out this slight overflow and renders it easily visible by such magnified elongation. By affixing the stem to a graduated scale this expansion of the mercury is measured, minus that of the glass containing it. If the glass and mercury expanded equally there would be no rise of mercury in the tube, as the capacity of the bulb would increase equally with its contents; but as the expansion of glass by heat is only about [illegible] of

that of mercury, $\frac{1}{26}$ of the actual expansion of the mercury is shown in the tube. The reading of a thermometer primarily indicates its own temperature; but if a thermometer is brought into intimate contact with another substance, as, for instance, if immersed in a liquid for a given time, the reading of the thermometer becomes higher or lower, according as the liquid is hotter or colder than the thermometer; and if the thermometer is left in contact with the liquid for a sufficient time, the reading of the mercury on the scale becomes stationary. In order to constitute a reliable thermometer the bore of the glass stem must be uniform throughout, otherwise the elongation of the thread of mercury would vary in different portions of the length of the stem, and the graduations of the scale would be affected. To test this equality the bore is *calibrated* by the simple device of passing a short thread of mercury along it, and observing as it moves forward if its length continues the same in every part; if not the tube is either rejected, or the variations marked and the scale adjusted accordingly by lengthening or shortening the divisions.

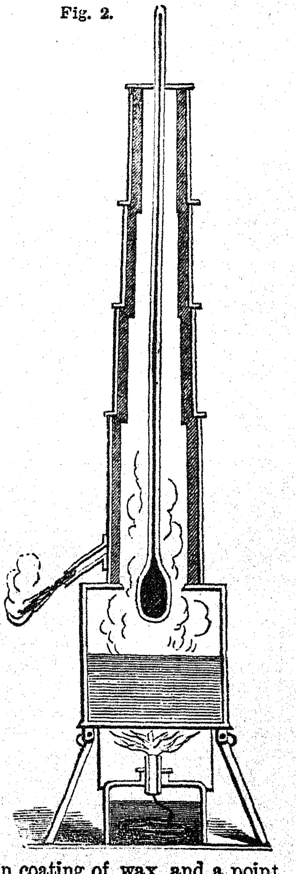
The bulb is formed by melting the glass at one end of the tube, so as to close it completely, and then blowing down from the other end, when the heated portion stretches out into a small bubble or globe. The accuracy with which the glass-blower, by constant practice, adjusts the size of the bulb to the diameter of the tube is such that grosses of common thermometer tubes are blown to suit grosses of scales already engraved, the same workman blowing within a fractional error tubes to suit scales of different lengths—one-eighth, one-tenth, one-twentieth, or other fraction of an inch to the degree, as required. The filling of the bulb with mercury through the small hair-like bore of the stem is effected by the expansive agency of heat. When the bulb is heated the air it contains is expanded and driven out, and if the end of the tube is at once immersed in a bath of mercury the liquid enters the tube as the air contracts by cooling, and partly fills the bulb. The mercury is then boiled in the bulb, and the whole space in the bulb and tube filled with vapour, the condensation of which leaves a vacuum which is rapidly replaced by the mercury in the bath, in which the open end of the tube is immersed. The filled tube and contents of the bulb are then raised to the highest temperature the thermometer is intended to register, and a blowpipe jet is thrown upon that part of the tube where the graduation for this temperature is to be marked. As the glass fuses it is drawn out and divided at this part by the action of the blow pipe in sealing the tube, which is then quite full of mercury. On cooling the mercury descends, leaving a vacuum in the upper part of the tube if the thermometer has been properly made. To test this vacuum the thermometer should be inverted; if the mercury runs down to the end of the tube it is perfect; if not, then air is left in the tube. As the thermometer is presupposed to embrace at least two fixed points of temperature—the freezing and the boiling points of water—it is the office of the thermometer to indicate them and the temperatures intermediate, through a certain number of equal stages or degrees. To determine the freezing point a box perforated in the bottom with a few holes to permit drainage is placed in a chamber where the temperature is above the freezing point of water. The box is then filled with pounded ice in a melting state, the temperature of melting ice under ordinary conditions being absolutely constant. The thermometer is then placed vertically in the ice, which is heaped up about the stem and allowed to remain so for fifteen minutes, when the mercury will have become stationary. The tube is then marked by a scratch at the termination of the mercury column, and thus the freezing point is determined. If the Centigrade scale is to be used this point will denote 0°; if the Fahrenheit scale, 32°. The boiling point of water is not constant, like the freezing point, for the temperature of steam in contact with water depends upon the pressure under which it is generated. Gay Lussac observed that water boiled at a higher temperature in a glass than in a metal vessel; but Rudberg pointed out that whatever the nature of the vessel, the temperature of the water, and not that of the steam, was altered. In fixing the boiling point the thermometer is therefore immersed into steam, and not boiling water, and if steam escapes from an open vessel containing boiling water into the air, the temperature of the steam will depend upon the amount of atmospheric pressure, which will be the same as that under which the steam is generated. The temperature of steam from water boiling in an open vessel will therefore vary with the height of the barometer. The commissioners appointed by the British government to verify standard weights and measures, and the Kew Committee of the British Association, have both decided that the boiling point of water shall be represented in London by the temperature of steam generated at the pressure of 29·905 inches of mercury. This accordingly is the correct meaning of 212° on the Fahrenheit scale and of 100° on the Centigrade scale of a thermometer.

TEMPERATURE OF STEAM AT DIFFERENT ATMOSPHERIC PRESSURES.

Temperature of Steam.	Pressure inches of Mercury at 32° Fahr.	Temperature of Steam.	Pressure inches of Mercury at 32° Fahr.	Temperature of Steam.	Pressure inches of Mercury at 32° Fahr.
211·0	29·315	211·7	29·727	212·4	30·143
211·1	29·374	211·8	29·786	212·5	30·203
211·2	29·432	211·9	29·845	212·6	30·263
211·3	29·491	212·0	29·905	212·7	30·323
211·4	29·550	212·1	29·964	212·8	30·384
211·5	29·609	212·2	30·024	212·9	30·444
211·6	29·668	212·3	30·083	—	—

When the atmospheric pressure is 29·905 inches, the boiling point is 212° Fahr. and 100° C. For any other pressures the true value of the boiling point is found in the above table. An arrangement of apparatus for determining the boiling point on the tube is shown in fig. 2. A closed metal vessel containing water is placed over a lamp. In the side is an open tube for the escape of the steam. The bulb of the thermometer is adjusted a little above the level of the boiling water, and so that the top of the mercury column is just visible; the tube of the thermometer is thus entirely surrounded by steam, and the rise of the column for the boiling point is marked on the tube. Regnault has devised an apparatus for determining the boiling point, somewhat in the form of a steam jacket, consisting of two cylinders with a space between them, the outside cylinder forming the jacket, and the thermometer is passed through the top of the jacket into the inner cylinder, which opens direct on to the vessel containing the boiling water. By this arrangement the steam passes up along the thermometer tube and down again into the outside jacket, from whence it leaves the apparatus by an opening in the side.

Fig. 2.



The distance between those two fixed points on the tube is graduated into equal divisions; or if it be desired to graduate the stem of the thermometer itself, the whole instrument is covered with a thin coating of wax, and a point attached to a dividing engine marks the graduations in the wax, exposing the surface of the glass. The thermometer is then dipped in hydrofluoric acid or exposed to its vapour, which attacks the glass where the wax has been scratched off. The graduations are usually extended above and below

the two fixed points. The freezing point on the scale of Fahrenheit being 32°, a temperature 32° below this point is termed zero; and one 10° lower, 10° below zero; and so on.

THERMOMETER SCALES.

The three thermometer scales at present in use are—the *Fahrenheit*, the *Centigrade*, invented by Celsius, and the *Réaumur* scale. The Centigrade is the most simple and natural, and is now coming into general use, especially in modern scientific works. In this scale the freezing point is 0° and the boiling point 100°, and the unit of temperature between freezing and boiling points is divided into 100 parts, called degrees.

In Fahrenheit's scale this natural unit is divided into 180 degrees, the freezing point reads 32° and the boiling point 212°, and the zero is 32° below the freezing point. The zero of this scale was determined by what was once supposed to be the lowest attainable temperature.

In Réaumur's scale the freezing point is zero, but there are only 80° between the freezing and boiling points. From the relative proportions of the degrees marked on each of these scales—

A degree Centigrade $=\frac{180}{100}$, or $\frac{9}{5}$ of a Fahrenheit degree;

" Fahrenheit $=\frac{100}{180}$, or $\frac{5}{9}$ of a Centigrade degree;

" Réaumur $=\frac{180}{80}$, or $\frac{9}{4}$ of a Fahrenheit degree;

" Fahrenheit $=\frac{80}{180}$, or $\frac{4}{9}$ of a Réaumur degree.

Or the following formula may be made use of:—To reduce

Fahrenheit to Centigrade, . . . $C=(F-32)\frac{5}{9}$.

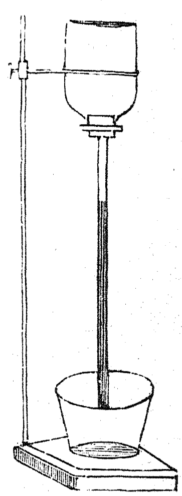
Centigrade to Fahrenheit, . . . $F=\frac{9C}{5}+32$.

Fahrenheit to Réaumur, . . . $R=(F-32)\frac{4}{9}$.

Réaumur to Fahrenheit, . . . $F=\frac{9R}{4}+32$.

However carefully thermometers may be constructed they are subject to various sources of error, which require to be taken into account. In the course of time it is found that the zero point has a tendency to rise, the displacement sometimes extending as much as two degrees, so that when the thermometer is immersed in melting ice it no longer sinks to zero in the tube. This is generally attributed to a diminution of the volume of the bulb and also the stem, arising from the continuous pressure of the atmosphere. With very accurate standard thermometers it is usual to fill them two or three years before the scales are graduated. In addition to this displacement of the zero, if the thermometer has been exposed to high temperatures, the stem and the bulb expand unequally, and on cooling do not always contract to their original dimensions. It is therefore necessary from time to time to verify the accuracy of the position of zero for delicate investigations of temperature. Regnault observed that in some mercurial thermometers, although the extreme fixed points of the scale (0° and 100°) might agree, frequent differences between these points existed to an error of several degrees. This he ascribed to the unequal expansion of different kinds of glass. When a thermometer has had its fixed points determined in a vertical position, it must always be used in this position; in the same way, if these points have been scaled in a horizontal position, the instrument must always be used horizontally—the reason being that for the same instrument and the same temperature the instrument will give a higher reading in the horizontal than in the vertical position, because in the latter the hydrostatic pressure of the column of mercury tends not only to compress the particles of mercury into less volume, but also by this increased weight to enlarge the volume of the bulb. As one portion of the stem is also not exposed to the influence of the steam in fixing the boiling point for all temperatures above this fixed point, a correction for expansion in the tube must be made when extreme accuracy is desired. In order to avoid the necessity of making this correction the entire tube, as well as the bulb, should be exposed to the temperature of the boiling point of water. Again, it must be borne in mind that an indicated rise of 50° takes place in a bore and tube of the temperature of 50°, and of which the capacity is smaller than when the temperature is 100°, in the proportion of 1·0013 to 1·0026. All these circumstances introduce errors necessary to be compensated when extreme accuracy is required with thermometrical measurements. For temperatures below −36° C. the mercurial thermometer is useless, as mercury solidifies at −40° C.; and above 100° C. the coefficient of the expansion of mercury increases, and the indications become only approximate. Mercurial thermometers cannot also be used for temperatures above 350° C., for this is the boiling point of mercury.

Fig. 3.



The original thermometer invented by Galileo was an *air* thermometer (fig. 3); it consisted of a glass bulb with a long stem. The air of the bulb was heated, and then the stem was plunged into a coloured liquid. As the air in the bulb cooled the liquid rose in the stem, and the higher the liquid the lower the temperature of the air in the bulb. By putting the bulb into the mouth of a patient, and observing the point to which the liquid is driven down the tube, a physician might judge whether the ailment was of a feverish nature or not. Such a thermometer has several merits: its construction is simple, and it gives larger indications for the same change of temperature; the air also requires less heat to warm it than an equal bulk of any liquid. The disadvantage of the instrument as a means of measuring temperature is, that the height of the liquid depends on the pressure of the atmosphere as well as the temperature of the air in the bulb. The air thermometer therefore, to be of any scientific value, must be used along with the barometer, and its readings are of no use until the requisite corrections have been made.

By means of an air thermometer, in which the reservoir was made of platinum, Pouillet measured the temperature corresponding to the colours which metals assume when heated in a fire:—

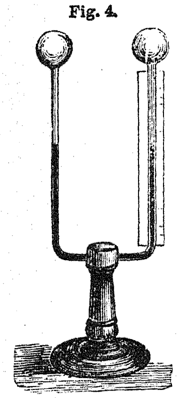
Incipient red, . .	525° C.	Dark orange, . .	1100° C.
Dull red, . . .	700	White, ...	1300
Cherry red, . . .	900	Dazzling white, .	1500

In measurements of very high temperatures Deville and Troost employed the vapour of iodine in place of air with advantage; and as platinum is found to be permeable to gases at high temperatures, they employed porcelain in place of platinum for the reservoir.

The *alcohol* thermometer is used for registering temperatures below the freezing point of mercury, for it does not solidify at the greatest cold known. Such an instrument is not capable of being constructed with the same amount of accuracy as a mercurial thermometer, but if used with caution may give satisfactory results. As the expansion of liquids is less regular in proportion as they approach the boiling point, alcohol, which boils at 78° C., expands very irregularly. Alcohol thermometers are therefore graduated by immersing them in baths at different temperatures, together with a standard mercurial thermometer. In this manner the alcohol thermometer is comparable with the mercury one, and it indicates the same temperature under the same conditions. When very careful observations are desired this thermometer should be placed in a vertical position, with the bulb downwards some little time before it is read. Alcohol, unlike mercury, *wets* the capillary glass tube, and is besides extremely volatile. Great care is therefore to be taken that there is no liquid either condensed or adhering to the sides of the tube above the main column.

Sir John Leslie has constructed a thermometer for indicating the temperature between two adjacent substances or places, which is called the *differential* thermometer. It consists of a bent glass tube, each end of which terminates in a bulb (fig. 4). The bend contains some coloured fluid which is not volatile: sulphuric acid is frequently employed. When one of the bulbs is at a higher temperature than the other the liquid in the stem is depressed, and rises in the other stem. The instrument is now only used as a *thermoscope*, to indicate a difference of temperature between the two bulbs, and not to measure its amount.

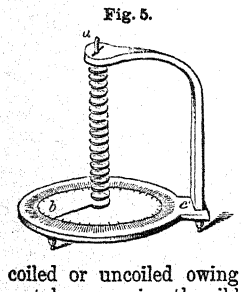
Fig. 4.



It is frequently important to know not merely the present temperature, but also the highest and lowest temperature of the day and night to which an instrument has been exposed. Meteorologists should be able to record every evening and morning the maximum and minimum temperatures of the atmosphere. Several instruments have been invented for this purpose, the simplest of which is Rutherford's. On a rectangular slab of porcelain or glass two thermometers are fixed, the stems of which are bent horizontally. In one is mercury, and in the other is coloured alcohol. In the first there is a minute piece of iron wire, moving freely in the tube, which serves as an index. The thermometer being fixed horizontally, as the temperature rises the mercury, expanding, pushes the index before it, but as soon as the mercury contracts the index remains stationary in any part of the tube to which it has been pushed, as there is no adhesion between the iron and the mercury. In this way the index registers the highest temperature which has been attained. The index is re-set by passing a small magnet downwards over the tube, the iron following the movement of the magnet. In the minimum thermometer a small hollow glass tube serves as the index. When it is at the end of the column, and the alcohol falls by decrease of temperature, the index is carried with it by adhesion until it has reached the greatest contraction; and when the temperature rises and the alcohol expands, the fluid passing between the sides of the tube and the index, it is not displaced. The position of this index, therefore, registers the lowest temperature reached.

A very sensitive metallic thermometer has been constructed by M. Breguet, of Paris, which depends on the unequal expansion of metals by heat. It consists of a spiral (fig. 5), composed of three strips of silver, gold, and platinum rolled together to form a very thin metallic ribbon. This ribbon is then coiled in a spiral form, and one end, *a*, being fixed to a support, a light index, *b*, is fixed to the other end of the spiral, and which is free to move round a graduated scale, *c*. In this state it is sensitive to an exceedingly small change of temperature, becoming coiled or uncoiled owing to the different expansion of the metals composing the ribbon. Silver, the most expansible of the metals, forms the internal face of the spiral, and platinum the external. The gold being intermediate in its expansibility between silver and platinum, is placed in the middle. Were the other two metals employed alone their rapid unequal expansion might cause a fracture. The scale is graduated in degrees by comparing its indications with those of a standard mercurial thermometer. The several forms of pocket thermometers depend on this principle.

Fig. 5.



Instruments for measuring temperatures beyond the range of the mercurial thermometer are termed *pyrometers*. The older forms of pyrometer, such as Wedgwood's, Daniell's, &c., which depended upon the expansion of a metal bar, are no longer in use, as their indications afforded only an approximation of the degree to which the temperature reached. The modern form of pyrometers is either based on the expansion of gases and vapours, or on the electrical properties of bodies, both of which forms will be subsequently described.

EXAMPLES OF IMPORTANT TEMPERATURES.

A few examples of the extremes of temperatures are tabulated, the thermometer scale used being the Centigrade.

Greatest artificial cold produced by a bath of bisulphide of carbon and liquid nitrous acid,	−140° C.
Greatest cold produced by ether and liquid carbonic acid,	−110
Greatest cold recorded in Polar expeditions,	− 57·7
Mercury solidifies,	− 39·4
Mixture of snow and salt,	− 20
Ice melts,	0
Greatest density of water,	+ 4
Mean temperature of London,	9·9
Blood heat,	36·6
Water boils,	100
Mercury boils,	350
Sulphur boils,	440
Red heat (visible, Daniell),	526
Silver melts,	1000
Zinc boils,	1040
Cast iron melts,	1530
Greatest heat of blast furnace,	1800
Platinum melts,	2000
Iridium melts,	2700

SPECIFIC HEAT.

The measurement of the temperature of a body gives no indication of its heat-power. The simple fact that in 2 lbs. of water at a given temperature the heat-power is greater than in 1 lb., while the thermometer registers no difference of temperature, is conclusive. Therefore, in comparing equal quantities of different substances their temperatures do not indicate their relative supplies of heat, for a pint of water, a pint of oil, and a pint of mercury, each at a temperature of 100° C., are equally hot, but this affords no indication that they possess an equal amount of calorific or heating power. Each one has a different density or gravitating power; thus the pint of water is denser than the pint of oil, volume for volume, and the pint of mercury is denser than the pint of water, and it will be found that each possesses a very different calorific power. A very simple method to determine their relative heating power is to ascertain how much heat is necessary for raising a given quantity of each through a certain range of temperature, and how much heat each one gives out to surrounding bodies in the process of cooling down through a certain number of degrees. It is found that when equal weights of water and mercury are exposed during equal times to the same heating or cooling influences, the temperature of the mercury will rise or fall about thirty times as much as that of the water. A similar result is obtained by mixing together equal weights of these fluids at different temperatures. If one pound of mercury at 100° C. be mixed with one pound of water at 7° C., the temperature of the mixture (allowing for loss of heat during mixing) will be about 10° C., the mercury having lost 90° C. in raising the water 3° C. But if the water be taken at 100° C. and the mercury at 7° C. the admixture will be found to have a temperature of 97° C.; that is, the water loses only 3° C. in raising the mercury 90° C. If, however, instead of taking equal weights of mercury and water, 30 lbs. of mercury is taken to one of water, the temperature after mixing will represent the mean of the original temperatures. Now, as mercury is thirteen and a half times heavier, volume for volume, than water, with equal volumes of these two liquids the water gives to the mercury more than twice as many degrees of temperature as it parts with in cooling, and it takes from the mercury more than twice as many degrees as it appears to gain when heated by the mercury. It is thus found that the amount of heat-force residing in different forms of matter of equal temperatures is subject to a variation similar

to that of the *density of equal volumes of the different substances*, and this variation of heat-power in different bodies is termed the *specific heat* of those bodies. The measure of this specific heat of bodies is termed *calorimetry*, the name being based upon the old conception of heat as a separate substance, expressed by the term *caloric.* Specific heat is measured by the amount of calorific work that can be performed. Thus, when a given quantity of coal is burned, by means of the thermometer or pyrometer the measure of the temperature may be determined, but this by no means represents the amount of energy or heat-power the coal has developed during the process of combustion. To measure this amount of heat which a body either absorbs or parts with when its temperature is changed to a given extent, or when it changes its state, a unit of some known substance of a known weight is taken, called the *thermal unit*, and this is in England the quantity of heat necessary to raise one pound weight of water through one degree centigrade.

Heat when absorbed by a body performs two distinct kinds of *work.* One portion of the heat excites that particular form of motion in the atoms of the body which raises its temperature. The other portion is expended in overcoming the mutual attraction of the atoms, pushing them wider apart, and thus causing the body to expand in volume, while at the same time it increases the intensity of their vibrations; this portion of the heat is lost. Heat thus not only imparts actual energy to the vibrating atoms, which goes to raise the temperature, but also performs the *internal work* of expansion by which external pressure is overcome. If this latter could be separated from the former the true *heat of temperature*, or the *specific heat* expended in increasing the *vis viva* of the atoms, would be obtained.

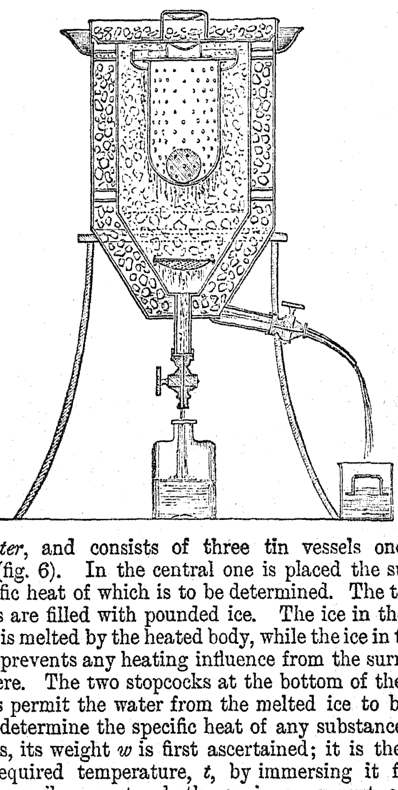
The science of chemistry has determined the relative weights of the atoms of different substances and gases. If an atom of hydrogen represents 1, the weight of an atom of oxygen is 16; therefore a pound weight of hydrogen will require sixteen times the number of atoms that are contained in a pound of oxygen, or the number of atoms will be inversely proportional to the atomic weight. The exhaustive experiments of M. Regnault, Tyndall, and others demonstrate that all elementary atoms when at the same temperature possess the same amount of energy or heat, the lighter atoms making up what they want in mass by increased energy of vibration. A pound of hydrogen therefore will contain sixteen times the amount of heat that a pound of oxygen will at the same temperature, and to raise a pound of hydrogen to a given number of degrees of temperature would require sixteen times the heat necessary to raise a pound of oxygen to the same temperature; and contrariwise, a pound of hydrogen in cooling through a given number of degrees would part with sixteen times the amount of heat that a pound of oxygen would in falling to the same temperature. As in gases there are no molecular attractions to be overcome, there is no sensible interior work to be performed; but in solids and liquids differences exist, not only in the number of atoms present in a unit of weight, but a portion of heat is expended in interior work; it is for this reason that the heat of a substance is not represented by its temperature.

Three methods are employed for determining the specific heats of bodies; namely, that of melting ice, the method of mixtures, and that of cooling, in which the specific heat of a substance is determined by the time it takes to cool through a certain number of degrees of temperature.

To obtain the formula expressing the amount of heat absorbed or given out by a substance of known weight and specific heat, when its temperature rises or falls through a given number of degrees, let w be the weight of the substance in pounds, s its specific heat, and t its temperature. The quantity of heat necessary to raise a pound of water through one degree being unity, w of these units will be required to raise w pounds of water through one degree, and to raise it t degrees, t times as much, $w\,t$. This therefore will be the quantity of heat necessary to raise through t degrees w pounds of water, the specific heat of which is unity, and a body of the same weight, but of a different specific heat, will require $w\,t\,s$, so that when a body is heated through t degrees, the amount of heat which it absorbs is *the product of its weight, into the range of temperature, into its specific heat.* This formula is the basis of all calculations for specific heats. If the body is cooled or heated from t to t' degrees, the heat liberated or absorbed will be represented by $w(t-t')s$, or $w(t'-t)s$.

The first who employed the melting of snow or ice to measure the amount of heat given off by bodies in cooling was Wilcke, a Swede, and Laplace and Lavoisier improved the apparatus to insure that all the heat liberated by the body was employed in melting the ice, and that no extraneous heat reached the ice to melt it, or escaped from the water so as to freeze it. This instrument is called the

Fig. 6.



calorimeter, and consists of three tin vessels one within another (fig. 6). In the central one is placed the substance the specific heat of which is to be determined. The two other chambers are filled with pounded ice. The ice in the middle chamber is melted by the heated body, while the ice in the outer chamber prevents any heating influence from the surrounding atmosphere. The two stopcocks at the bottom of the two ice chambers permit the water from the melted ice to be drawn off. To determine the specific heat of any substance by this apparatus, its weight w is first ascertained; it is then raised to the required temperature, t, by immersing it for some time in an oil or water bath, or in a current of steam. Having then been quickly placed in the central compartment, the lids of the respective chambers are replaced after the two external chambers have been completely filled with pounded ice; the water which flows out by the stopcock R is collected, and its weight will be that of the melted ice in the middle chamber; and as one pound of ice at 0° C. in melting to water at 0° C., absorbs 80 thermal units, P pounds absorb 80 P units; but this quantity of heat is equal to the heat given off by the body in cooling from $t°$ to zero, which is $w\,t\,s$, and therefore

$$w t s = 80 t°, \text{ and } s = \frac{80\,\mathrm{P}}{w\,t}.$$

The objections to this form of apparatus are its large size, the quantity of ice necessary, and the length of time required for the experiment, while also a certain amount of water remains adhering to the ice, so that the water drawn off at R does not exactly represent the weight of the liquefied ice.

Another method, by the fusion of ice, is based on the fact that to liquefy a pound of ice 80 thermal units, or 79·25 in exact measurement, are required. Upon this principle Black's calorimeter is devised; it consists of a mass of ice in which a cylindrical cavity is hollowed out, and provided with a cover of a thick slab of ice. The substance the specific heat of which is to be determined, after being heated to a certain temperature, is quickly placed in the ice chamber

and closed in by the ice block. When sufficient time has elapsed to reduce the body to zero it is removed from the chamber, and both the body and the cavity wiped dry with a sponge, the weight of which has been previously ascertained. The increased weight of the sponge represents the amount of ice which has been liquefied by the body in cooling.

Bunsen's ice calorimeter depends upon the diminution of volume which ice undergoes in conversion into water, and is employed when only a small mass of the substance the specific heat of which has to be determined can be obtained. The apparatus is not only small, but exceedingly accurate in its results. Its construction is as follows:—A small glass test tube, intended to receive the substance experimented upon, is fused into a wider tube, so as to leave the mouth of the test tube open; the lower end of the larger tube is bent round, and prolonged upwards into a somewhat narrower tube, at the top of which is firmly fixed a capillary tube graduated with divisions determined by measurement. The upper portion of the outside tube surrounding the test tube is filled with fresh boiled distilled water, perfectly free from air, and the prolongation of this tube and the capillary tube with mercury. When the apparatus is immersed in a freezing mixture the water surrounding the test tube is quickly frozen, and if then the apparatus is protected from the influence of external heat, and a weighed quantity, at a given temperature, of the substance the specific heat of which has to be determined, is introduced into the test tube, it imparts its heat in cooling to the external jacket of ice, by which a certain quantity is liquefied, the increased bulk of which, on liquefaction, depresses the mercury in the lower portion of the tube, the measure of which is read off upon the graduations of the capillary tube. Thus the weight of ice melted by the quantities of heat emitted from the test tube into the calorimeter may be compared with the indications of the extremity of the column of mercury in the capillary tube, the motions of which are always proportional to the quantity of heat. By means of this apparatus Bunsen has accurately determined the specific heat of the rarer metals, which can only be obtained in very small quantities. The substance is heated in another test tube by a steam bath until it has acquired the temperature of boiling water; the tube then is rapidly removed and the contents emptied into the tube of the calorimeter.

In determining the specific heat of a substance by the method of mixture, it is weighed and afterwards raised to a given temperature by immersion in a steam bath. It is then immersed in a mass of cold water, the weight and temperature of which are known. The temperature of the water after a time will cease to rise, when the specific heat of the substance may be obtained by calculation. Let W be the weight of the substance, T its temperature, s its specific heat; and let w be the weight of the cold water, and t its temperature. On plunging the heated body into the water its temperature rises until both are the same. Let this temperature be X. Then the heated body has been cooled by $T - X$. It has therefore lost an amount of heat $L(T-X)s$. The water, on the contrary, has absorbed a quantity of heat equal to $l(X-t)$, the specific heat of water being unity; and as the quantity of heat parted with by the body is equal to the quantity of heat taken up by the water, $L(T-X)s = l(X-t)$, from which $s = \frac{l(X-t)}{L(T-X)}$. For example, if a piece of lead weighing 16 oz. at a temperature of 100° C. is immersed in 16 oz. of water, whose temperature is 14° C., and after the temperatures have become uniform, that of the water is found to be 17° C., the specific heat of the lead will be

$$s = \frac{16(17-14)}{16(100=17)} = \frac{C}{166} = 0{\cdot}00361.$$

Thus, the lead heated 83° C. and gave out 3° C. of heat to the water, or the same amount of heat which raises a pound of water. 3° C., or from 14° C. to 17° C., will heat a pound of lead 83°, or from 17° C. to 100° C.; or in general terms, to raise a pound of lead 3° C. requires about one-thirtieth part of the heat needed to raise one pound of water 3° C. This is expressed by saying that the capacity of lead for heat is one-thirtieth of that of an equal weight of water.

Certain corrections require to be made in calorimetrical results, as the vessel containing the substance originally at the temperature of the cooling water shares its increase of temperature, and this must be allowed for; therefore as the decrease of temperature of the heated body is equal to the increase of temperature of the cooling water, and of the vessel in which it is contained, if the weight of the latter be w', and its specific heat s', its temperature, like that of the water, is t; therefore the equation becomes

$$Ls(T-X) = w(X-t) + w's'(X-t),$$

$$\text{or } s = \frac{(w+w's')\,(X-t)}{L(T-X)}.$$

As a rule the value $w's'$ is represented by μ, which therefore is the weight of water which would absorb the same quantity of heat as the vessel. This therefore gives the *reduced value* in water of the vessel, or the *water equivalent*, and the equation becomes $s = \frac{(w+\mu)\,(X-t)}{L\,(T-X)}$. In very accurate experiments allowance is also made for the heat absorbed by the glass and mercury in the thermometer. The loss of heat due to radiation of the heated body has also to be estimated, and consequent increase of temperature of the cooling water. This is determined by experiment.

A method of determining the specific heat of liquids which depends on a property of the electrical current of heating any conductor of high resistance through which it passes, is frequently employed with advantage. Two similar calorimeters are fitted with suitable thermometers and stirring appliances, and into each is introduced a coil of fine platinum wire of equal length and resistance. On the ends of these wires being connected with a voltaic battery, and the current simultaneously passed through them, the heat produced in the wires will be equal, and the rise in temperature in the liquids will be inversely as the specific heats. One of the liquids employed is usually water. From its great specific heat water occupies a long time in being heated or cooled, and for the same weight and temperature it absorbs and gives out a much larger amount of heat than any substance. It is this dual property of water, which is one that performs a most important part in the economy of nature, that is made use of in hot-water apparatus.

The following table gives the relative amounts of specific heat given out by a unit of weight of some elementary substances in cooling from 98° C. to 15° C., as determined by the experiments of Regnault; and since the discovery by Dulong and Petit of the remarkable law that *the product of the specific heat of any solid substance into its atomic weight is approximately a constant number*, a knowledge of the specific heat of substances is one of great importance:—

	Specific Heat.	Atomic Weight.	Atomic Heat.
Aluminium,	0·2143	27·4	5·87
Antimony,	0·0513	122·0	6·26
Arsenic,	0·0814	75·0	6·17
Bismuth,	0·0308	210·0	6·47
Bromine,	0·1129	80·0	6·74
Cadmium,	0·0567	112·0	6·35
Cobalt,	0·1067	58·7	6·26
Copper,	0·0952	63·5	5·99
Gold,	0·0324	197·0	6·38
Iodine,	0·0541	127·0	6·87
Iron,	0·1138	56·0	6·37
Lead,	0·0314	207·0	6·50
Magnesium,	0·2499	24·0	5·94
Mercury,	0·0332	200·0	6·64
Nickel,	0·1086	58·7	6·41
Phosphorus,	0·1740	31·0	5·39
Platinum,	0·0329	197·5	6·40
Potassium,	0·1696	39·1	6·47
Silver,	0·0570	108·0	6·16
Sulphur,	0·1776	32·0	5·70
Tin,	0·0555	118·0	6·55
Zinc,	0·0955	65·2	6·23

The specific heat is greater in the liquid than in the solid state, thus:—

	Solid.	Liquid.
Water,	0·489	1·000
Sulphur,	0·203	0·234
Bromine,	0·084	0·110
Iodine,	0·054	0·008
Mercury,	0·031	0·033
Phosphorus,	0·190	0·202
Tin,	0·056	0·064
Lead,	0·031	0·040

The specific heat of water is generally taken as unity, but according to the most recent determinations it is expressed by the formula $1 + 0·00015t$.

Dulong and Petit were the first to demonstrate experimentally that the specific heat of a solid is greater at a high temperature than at a low one, with the exception of platinum, for which the specific heat remains the same within the range of temperature.

Substance.	Mean Specific Heat.	
	Between 0° and 100° C.	Between 0° and 300° C.
Iron,	0·1098	0·1218
Zinc,	0·0927	0·1015
Antimony,	0·0507	0·0549
Silver,	0·0557	0·0611
Copper,	0·0949	0·1013
Platinum,	0·0355	0·0355
Glass,	0·1770	0·1990

M. Pouillet by employing the method of mixtures has succeeded in obtaining the specific heat of platinum at very high temperatures—viz.

Between 0° and 100° C.,	0·0335
" 0 " 300	0·0343
" 0 " 500	0·0352
" 0 " 700	0·0360
" 0 " 1000	0·0373
" 0 " 1200	0·0382

This constancy of the specific heat of platinum renders it serviceable as a pyrometer for estimating the temperature of a furnace. A piece of platinum, on attaining the temperature of the furnace, is at once immersed into a known volume of water at 0° C. The rise of temperature in the water enables the temperature of the platinum to be approximately ascertained, as well as that of the furnace.

The determination of the specific heat of gases is a problem of great practical difficulty, from the extreme delicacy of the processes necessary, and the small quantity of material contained in a large volume of the gas. The experiments of M. Regnault have determined the specific heat of gases under constant pressure, and also under constant volume. A gas, when it is heated, expands, and this is termed *specific heat under constant pressure.* If the gas, as it is heated, is kept at a constant volume, its pressure will be increased, and it has a different capacity for heat. This is termed *the specific heat under constant volume.*

SPECIFIC HEATS.

Simple Gases.

	Equal weights.	Equal volumes.
Air,	0·2374	0·2374
Oxygen,	0·2174	0·2405
Nitrogen,	0·2438	0·2370
Hydrogen,	3·4090	0·2359
Chlorine,	0·1210	0·2962

Compound Gases.

	Equal weights.	Equal volumes.
Binoxide of nitrogen,	0·2315	0·2406
Carbonic oxide,	0·2450	0·2370
Carbonic acid,	0·2163	0·3307
Hydrochloric acid,	0·1845	0·2333
Ammonia,	0·5083	0·2966
Olefiant gas,	0·4040	0·4106

Vapours.

Water,	0·4805	0·2984
Ether,	0·4810	1·2296
Alcohol,	0·4534	0·7171
Turpentine,	0·5061	2·3776
Bisulphide of carbon,	0·1570	0·4140
Benzole,	0·3754	1·0114

When a gas has its temperature raised $t°$ while the pressure remains constant, its volume will have increased to a certain extent; but if it is so compressed as to occupy its original volume, its temperature will again be raised to a certain extent $t'°$. Therefore the same quantity of heat which raised the temperature of a given weight of gas $t°$ while the pressure remained constant and the volume altered, will raise the temperature $t° + t'°$ if the gas is kept at a constant volume but variable pressure. The specific heat of a gas at constant pressure, c, is therefore greater than the specific heat under constant volume, c_1, and they are as $t + t' : t$, or $\frac{c}{c_1} = \frac{t+t'}{t}$. Recent experiments give the value 1·405 for $\frac{c}{c_1}$.

The capacity of gases for heat is not sensibly affected by their density, as the experiments of M. Regnault have proved, but apparent changes of specific heat may occur when change of temperature is combined with mechanical changes. In all mechanical operations in which power is expended on a body, as in compression, percussion, and friction, heat is produced; and in all mechanical changes in which power is gained or exerted by a body, as in expansion, heat disappears. Great pressure causes very sensible evolutions of heat. This is well seen in the process of coining, where the blank piece in sustaining the sudden and violent pressure of the coining-press becomes suddenly warm.

The very high specific heat of water exercises a beneficent influence in moderating climate. The specific heat of air being less than one-fourth of that of water, when a current of cold air is in contact with warmer water the air becomes warmed and the water is cooled. A pound of water, in parting with one degree of its heat, raises a pound of air more than 4 degrees, or over 4 lbs. of air one degree. But as a pound of air occupies about 814 times the space of one pound of water, a cubic foot of water, in cooling down one degree, raises 3·256 cubic feet of air one degree. Dr. Forel, making some experiments on the temperature of the Lake of Geneva, calculated that the amount of heat the water communicated to the air in the course of five days was equivalent to that which would have been evolved by the combustion of 1,250,000 tons of coal. The mild temperature of Torquay, exposed as it is on the east side to the open sea, is entirely due to the agency of the specific heat of the sea warming the winds before they reach land.

LATENT HEAT.

When the temperature of a solid body, as a piece of ice, is raised, the ice slowly melts into a liquid, and if the temperature is increased the liquid is converted into vapour. The heat applied in the melting of the ice has performed the *internal work* of overcoming the mutual attraction of the molecules forming the mass of the ice; and the conversion of the liquid into vapour by the heat has likewise demanded *internal work* in the separation of the molecules of water, and a certain amount of *external work* in addition in overcoming the pressure of the atmosphere when the liquid is converted into vapour. The amount of heat required to change a certain quantity of a solid (at the melting point) into a liquid *without raising its temperature* is called *the latent heat of fusion.*

When heat is applied to a pound of ice, the ice melts gradually, and the temperature of the liquid will be found to be that of the ice, 0° C., and although more heat may be applied to convert the ice into water, no rise in the temperature of the liquid takes place so long as any portion of the ice remains unmelted. A thermometer placed in the liquid will remain stationary at 0° C. This amount of heat (79·25° C.), which has been absorbed by the pound of ice to melt it without increasing the temperature of the fluid, is the *latent heat of water;* so that water at 0° C. = ice at 0° C. + latent heat. Consequently, if a pound of water at 79·25° C. is mixed with a pound of water at 0° C., the temperature of the mixture will be 39·62½° C.; but if, on the contrary, a pound of ice at 0° C. is mixed with a pound of water at 79·25° C., 2 lbs. of water are obtained at 0° C.; so that to melt a pound of ice to a pound of water of the same temperature requires as much heat as would raise a pound of water to 79·25°C. This absorption or apparent disappearance of heat was discovered by Black in 1757, who observed that in order to convert water at the boiling point (100° C.) into steam of the same temperature, a large amount of heat (537·2° C.) must be communicated to it, and also that steam at 100° C. gave out a large quantity of heat on being condensed into water, which remained at the same temperature, 100° C., and he expressed this quantity of heat by saying that the *latent heat of steam* is 537·2° C. Therefore steam at 100° C. = water at 100° C. + latent heat of vaporizing. *Latent heat therefore is the quantity of heat which must be communicated to a body in a given state in order to convert it into another state without changing its temperature.* The latent heats of fusion of various other liquids besides water have been investigated by Regnault, Person, and others, with the following results in thermal units:—

Water,	79·25	Cadmium,	13·66
Nitrate of soda,	62·975	Bismuth,	12·640
Nitrate of potassa,	47·371	Sulphur,	9·368
Zinc,	28·13	Lead,	5·369
Platinum,	27·18	Phosphorus,	5·034
Silver,	21·07	Mercury,	2·83
Tin,	14·252		

Regnault, in determining the latent heat of steam at low pressures, demonstrated that if a kilogramme of water at 0° C. was heated without evaporation to 100° C., and at that temperature wholly converted into steam, the total amount of heat required to perform this would be 637 units. The latent heat of steam at any temperature may therefore readily be ascertained from the total heat given in the subjoined table, which tabulates the results of all Regnault's experiments.

For instance, it takes 637 units first to heat a kilogramme of water at 0° C. to 100° C., and then to evaporate it at that temperature, but as it requires about 100 units to heat it from 0° to 100° C., 637 − 100 (or 537 units) represents the latent heat of steam at 100° C.

Temperature of the Vapour.	Total Heat expended.	Temperature of the Vapour.	Total Heat expended.
0° C.	606·5	120° C.	643·1
10	609·5	130	646·1
20	612·6	140	649·2
30	615·7	150	652·2
40	618·7	160	655·3
50	621·7	170	658·3
60	624·8	180	661·4
70	627·8	190	664·4
80	630·9	200	667·5
90	633·9	210	670·5
100	637·0	220	673·6
110	640·0	230	676·6

Various experiments to determine the latent heat of vapours have been made by Favre, Silbermann, and Andrews, the liquids always being evaporated at 100° C. The results obtained by Andrews are as follows:—

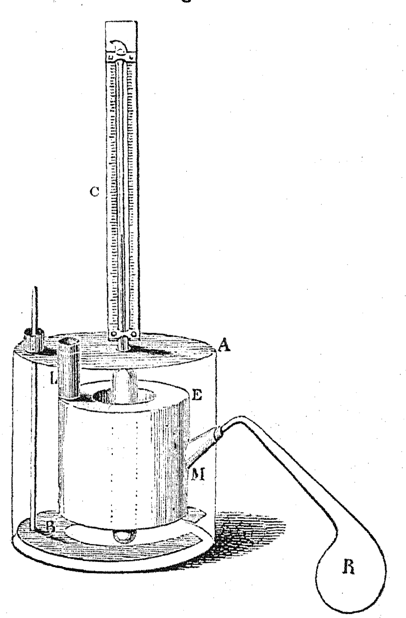
LATENT HEAT OF VAPOURS.

	Thermal Units.	Steam=1.
Water,	537·2	1·000
Wood spirit,	263·7	0·492
Alcohol,	202·4	0·378
Formiate of methyl,	117·1	0·219
Acetate of methyl,	110·2	0·206
Formic ether,	105·3	0·196
Acetic ether,	92·68	0·173
Ether,	90·45	0·169
Bisulphide of carbon,	86·67	0·162
Oxalic ether,	72·72	0·136
Terchloride of phosphorus,	51·42	0·096
Iodide of ethyl,	46·87	0·087
Iodide of methyl,	46·07	0·086
Bromine,	45·60	0·085
Perchloride of tin,	30·53	0·057

The thermal unit here adopted is the amount of heat required to raise one pound of water one degree Centigrade.

In determining the specific heat of vapours the vapour is produced in a retort, R (fig. 7), where its temperature is

Fig. 7.



registered by a thermometer. From the retort it passes into the condenser E L M, immersed in a vessel of cold water, A, where it is condensed, imparting its latent heat to the condensing water. The condensed vapour is collected in the vessel, E L M, and the amount of vapour condensed will be represented by its weight. A thermometer, C, in the condensing water gives the change of temperature, a stirrer, B, securing uniformity of temperature. Let W be the weight of the condensed vapour, T its temperature on entering the worm, and x the latent heat of vaporization. Again, let w represent the weight of the condensing water (including the weight of the vessels used reduced in water), and $t°$ the temperature of the water in A at commencement, and x its final temperature, and also that of the condensed vapour in E L M. The vapour W, after condensation, will have parted with an amount of heat, $W(T-X)c$. The heat disengaged in liquefaction is Wx, and the amount of heat absorbed by the condensing water and the vessels is $w(X-t)$. Consequently $Wx+W(T-X)c=w(X-t)$, from which the value, x, the latent heat of vaporization, is obtained.

Count Rumford first accurately determined the mechanical value of latent heat in the calorific power of fuel. He estimated the heat-producing power of a substance by the

number of parts by weight of water that would be raised one degree in temperature by one part by weight of the substance on perfect combustion. Thus one pound of charcoal, in combining with $2\frac{2}{3}$ lbs. of oxygen to form carbonic acid, produced heat sufficient to raise 8000 lbs. of water 1° C.; and one pound of hydrogen, in combining with 8 lbs. of oxygen to produce water, generated heat sufficient to raise 34,000 lbs. of water 1° C.; thus he determined the calorific powers of carbon and hydrogen to be as 8 to 34. Tyndall gives the mechanical value of the latent heat thus produced; the mechanical value of the force represented by the heating of one pound of water to 1° C. is equivalent to 1·390 foot-pound, and therefore the heating of 34,000 lbs. of water 1° C. will represent 34,000 × 1·390 foot-pounds. Thus the attractive power of the atoms of one pound of hydrogen and those of 8 lbs. of oxygen is equivalent in mechanical value to the lifting of 47,000,000 lbs. one foot high. Although the distances which separate the atoms are so minute as to be inappreciable, yet in passing over these distances the velocity they acquire is so vast as to cause them to strike one another with this enormous energy.

After the atoms have combined to form vapour, it sinks to the temperature of 100° C., and afterwards condenses into water. The mechanical value of this act may also be computed: 9 lbs. of steam in becoming water generate heat sufficient to raise 537·2 × 9 = 4835 lbs. of water 1° C., and multiplying this number by 1·390 a product of 6,720,000 foot-pounds is obtained as the mechanical equivalent of the act of condensation, and if the liquid is reduced to ice (0° C.) a further development of mechanical energy takes place, representing 993,564 foot-pounds.

The law of Charles, or Gay-Lussac, determines the increase of volume in gases, including vapours, under the influence of temperature, and is expressed as follows:— *When a portion of gas under a constant pressure is raised from* 0° C. *to* 00° C. *its volume will increase by equal fractions of itself for each degree of temperature*, and this law holds good whatever be the nature of the gas.

If a mass of air at the ordinary pressure is inclosed in a tube of uniform diameter by means of a drop of mercury, and the air column is 30 inches long from the heated end when cooled down to 0° C., if the tube is heated to 100° C. the air column will elongate from 30 to 41 inches, or a little more than one-third of the volume, the exact value of which, as determined by Regnault, is ·3665. If V°, V^t be the volumes of a mass of a gas at temperatures 0°, t° respectively, and $a = \cdot003665$, then the increase of volume of the gas from 0° to t° under a *constant pressure* is $V^\circ\, a\, t$, therefore $V^t = V^\circ(1+at)$, and therefore the expansion for 1° C. is $\frac{\cdot3665}{100}$, or $\frac{1}{366}$ of the volume at 0° C. The practical importance of this law in the ventilation of mines is very great, as it indicates the amount of work to be done by a furnace, and regulates the volume of air thrown into the mine. For instance, at the Haswell Colliery, where the upcast shaft is 936 feet deep, and the mean temperature of the air is maintained at 73° C., while the mean temperature of the downcast shaft is 10° C., the furnace sends 94,960 cubic feet of air per minute through the mine at a temperature of 10° C., and does the work of lifting the air which traverses the mine 170 feet, the difference between the column of heated air 936, and the cooled column 766 feet, and as the quantity of air passing up the shaft is 94,960 cubic feet, the weight of which is about 7407 lbs., the work done represents 125,910 foot-pounds. The amount of coal consumed by the furnace per minute being 8 lbs., the mechanical equivalent per 112 lbs. of coal, or the duty performed, is 17,628,660 foot-pounds.

If it is required to find the general proportion between the pressure, temperature, and density of a mass of gas, and p^t, t, q^t be the pressure, temperature, and density of the mass, then, according to Boyle's law, q^t varies as p^t when t remains constant; and by Charles' law when p^t remains constant the volume of gas at $t^\circ = (1+at) \times$ volume of gas at 0° C., or the density at 0° C. $= (1+at) \times$ density at $t^\circ = q^t(1+at)$. Consequently q^t varies as $\frac{1}{1+at}$ when the pressure is constant. Therefore, when both the pressure and temperature vary, q^t varies as $p^t \times \frac{1}{1+at}$, or p^t varies as $q^t(1+at)$, or $p^t = \mu q^t(1+at)$, where μ is a constant. If the volume and the density remain constant while the temperature rises, the pressure will also rise. Therefore $p^t = \mu q^t(1+at)$, and $p^\circ = \mu q^t$ when $t=0$, since q^t does not change. Therefore $p^t = p^\circ(1+at)$. In these formulæ it is understood that when a mass of air, the temperature of which is 0° C., is heated to 100° C., its pressure is raised from 1 to 1·3665, being a rise of ·003665 for each degree of temperature.

LOGIC.—CHAPTER VIII.

SYLLOGISMS DEFINED AND EXEMPLIFIED—RULES GOVERNING THEIR STRUCTURE, MOOD, AND FIGURE EXPLAINED.

THE mind formulates that it may understand; in fact, we think in *forms*, hence we say one to another, "Put your idea, plan, proposal, &c., in form." The type-form of thought is the syllogism. To syllogize is to think in proper form. Logic does not frame the fashion of reasoned thought; it learns by the inductive observation of convincing arguments the shapes which reasoning must take in order that it may satisfy the most intelligent and trustworthy minds—those the correctness of whose habit of thought has been practically tested by application to the conducting of important affairs. *Form* is the bounding and containing line of a material object, and it is by analogy used of anything by which thought is limited and brought within definite circumscription. In this way speech becomes the form of thought, and syllogism the form of thought in speech which is logically valid. Speech is always enunciative, *i.e.* it represents what passes in the mind. It is significative, however, only when—and so far as—it is the *sign* of a reality lying behind it. The reality is required to fill in and up the form. Otherwise we treat every saying in which there is no reality as "mere empty forms of speech." If I should say,

> All poisons are detrimental to health;
> Water is a poison;
> Therefore water is detrimental to health,

the syllogism, though correct in form, is a mere empty form, for it is not in the minor significative of truth. But if I say,

> All poisons are detrimental to health;
> Night-soil tainted water is poisonous,
> And is therefore detrimental to health,

I am right, because the form is filled up by and made significant of the reality. Syllogism is the form in which thoughts link themselves together rationally—the express and expressive representation of a perception of truths in strict and orderly relationship one with another—the correct logical form of stating a process of reasoning thought. Aristotle defines syllogism as "speech in which certain things being laid down [or stated] something else different from the things laid down [or statements made] results by virtue of their being so laid down; and 'by virtue of their being laid down' I mean that it results through them, and I mean by 'resulting through them' that there is no need of any external term for the necessity to be" (Prior Analytics, I. i. 6). The necessity does not require to be expressed in the syllogism, because it is implied in the use of speech that it be significative of what is true before it be made enunciative. When speech is presented for acceptance as enunciative of the true, and is accepted as such, the syllogism shows the specific form in which the truths so enunciated must be linked together that they may yield valid and trustworthy conclusions. The logical validity is not conferred upon the syllogism by its form, but because we know, by observation and experience, that where truths are enunciated in the relations on which logic insists, they have always been found to result in correct conclusions of the kind stated. Unless thought can be placed in syllogistic relation with thought we know that an infallibly correct

inference cannot be made. But it does not follow that because thoughts can be placed in syllogistic relation to one another, the conclusion which results must be infallibly correct. Each *idea* must conform to and represent a reality; each *proposition* must state the precise truth concerning its matter; and each *syllogism* must be co-linked rightly in all its relations. Hence induction lies behind syllogism, and supplies syllogism with its material truths.

Formal logic shows the precise and exact form which rationally arranged thought must take to yield trustworthy results. But formal logic demands not only that the thought presented to it shall, in reality and in truth, represent, in its enunciation, the proper thought, but that the thought shall itself adequately and truthfully embody the fact correctly seen, rightly verified, and fully examined. The objective truth which investigation and reflection have made the subject of predicative enunciation must be distinctly and definitely brought into the form of a true proposition, and that be again linked rightly with another true proposition, if a true conclusion is to be syllogistically elicited from them; and only so far as the propositions which form the premises are themselves truly and discriminatively expressive of veritable facts (moral, natural, philosophical, mathematical, &c.), justly linked in right relationship, is the conclusion derived from them demonstrative. The premises must be unchallengeable in their statements, and legitimately arranged according to their enunciative force in quantity and quality, into specific moods and figures, and then the conclusion is irrefragable. Syllogism is the proper scientific form in which two statements are brought together in accordance with the laws of thought, and are so compared with a third that the connection between them is indubitably determined, and what is called validly demonstrated. Demonstration consists in showing the absolute and inevitable necessity of accepting certain conclusions as distinct and trustworthy inferences from true premises rightly related; it is syllogistic reasoning.

The syllogistic form is not the essence of logical reasoning, but no really convincing and trustworthy reasoning has ever commended itself to the highest and best minds as conclusive in any other form than that which the syllogism exhibits (or in a form easily reducible to the syllogistic combination). Every idea receives from experience, observation, scientific induction, &c., the signification it is to hold in the mind's eye as *eidos*, a mental apprehension of an *idea* or counterpart in nature or experience. Unless these two coincide, it is evident that not one, but two, different notions are really (or at least possibly) posited in the words used; *e.g.* the circle in an amphitheatre might be the counterpart matter of a mental apprehension, while the mental apprehension itself might be a circle as geometrically defined. Every proposition is a forth-placing of a statement accepted by one judgment, that of the [thinker or] speaker, and presented to the judgment of another for acceptance. It is, again, undoubted that if the proposition does not set forth the actual fact and reality at once of things and thoughts, or if it is not accepted by another mind exactly as it is meant (either from defect of expression in the statement made or of impression taken by the hearer's mind), the propositions founded on are in reality not the same, but different. If I say, for instance (the instance, of course, is glaring, that it may attract attention), "Capes are comfortable"—referring to certain bodily coverings—and somebody overhearing the remark ejaculates, "Oh! I'm so glad to hear that, for my brother has just gone out to the Cape," the proposition in my mind is quite different from that excited in my hearer's and accepted as a ground of comfort. Each syllogism also must be legitimately arranged so as to establish distinctly what is inferred, and must not (or at least ought not to) enlarge or diminish in the conclusion what has been secured as inferentially true in the premises. If I argue—

> Nothing essential to life should be wasted,
> Food is essential to life;
> Therefore no food should be wasted,

the commendableness of my conclusion may, perhaps, not awaken the mind to the fact that it has not been legitimately attained. An illicit process has been introduced. I have not in the minor asserted that all food is essential to life, nor could I probably prove that proposition, though I should have no difficulty in receiving acceptance for the statement, "Some food is essential to life." As that is all that my minor premise can really signify I am only entitled to deduce from my premises the rather weak conclusion, "Some food should not be wasted." This illegitimate reasoning would be immediately detected if I were to say—*apropos* of a conversation on gambling, for instance—

> Nothing that is essential to health is sinful;
> Play is essential to health;
> Therefore no play is sinful.

It is to guard against false or erroneous reasoning, either in our own minds or in the conversation, speech, or writings of others, that an examination of the forms of reasoning have been undertaken by students of psychology under the name of logic. We may not all be able to follow the processes of research which men of science have pursued with keen avidity, till they have wrung her secrets from nature and have worked them into expressions meant to transfer their idea to our minds, and we must, therefore, frequently rely upon their definitions for the means of forming some idea of what they intend, and accept their propositions as statements of the actual relations and significations of things. Readily accepting these as the results of recondite research, we listen to their reasonings with curiosity and interest, and we have only the form of right reasoning in our possession as a safeguard against being hurried into hasty and perhaps ill-judged conclusions; *e.g.*

> The rushing of particles to a nucleus causes bodies so formed to rotate;
> The earth rotates;
> Therefore the earth was formed by the rushing of particles to a nucleus,

is not, as it stands, a valid syllogism. It requires that the major premise be given as, "All bodies which rotate are formed by the rushing of particles to a nucleus," and this suggests that we should inquire whether the premise given asserts and implies that all bodies (and these alone) which are formed by the rushing of particles to a nucleus rotate. In this way we see how a knowledge of the form may help us in attaining the reality of truth.

The utility of an acquaintance with the scientifically certified forms of syllogism is fourfold:—(1) It prevents the misdirection of power in seeking to express reasoning in forms which have been found to be unconvincing; (2) it inspires us with confidence in our deductions when we find that what we think complies in its results with the forms which have been found to be convincing after the thorough testing of the best thinkers; (3) it imparts to the mind a ready power of placing thought before the minds of others in forms which enable us to point out and then to discern the precise character and relation of every link in any chain of reasoning; and (4) it enables us to perceive more readily the incidence of argument and its coincidences or disagreements with consistent thought and reality.

It is plain that if two ideas, each sufficiently well understood by the mind, are brought before the consciousness simultaneously, they must (in the large majority of cases at least) impress the mind with the conviction that (1) they can be thought of together in some relation or other; or that (2) they cannot be thought of together in any relation. Again, if two ideas have been separately compared—*i.e.* brought before the mind to have their likeness or relationship brought to the test—with a third (which is precisely the same in substance and relation in each case), they may be afterwards compared with each other in regard to that same point. In this form of thought the mind postulates and acts upon the two following axioms:—

1. If two terms agree with one and the same third, they agree with each other.
2. If one term agrees and another disagrees with one and the same third, these two disagree with each other.

On the former of these rests the validity of *affirmative* conclusions; on the latter of *negative* ones.

The principle of the categorical syllogism is exceedingly simple. Every such syllogism contains three terms—(1)

major, (2) minor, (3) middle—and must have no more than these three terms; and is composed of three propositions—(1) major premise, (2) minor premise, and (3) conclusion—and must have no more than these three propositions. In the major premise the major term is compared with the middle term; in the minor premise the minor term is compared with the middle term. The conclusion brings the major and the minor terms together for comparison. The major term is the predicate and the minor the subject of the conclusion; *e.g.*

Every virtue is laudable; Diligence is a virtue; Diligence is laudable.	Or	No vice is laudable; Diligence is laudable; Diligence is no vice.

1. The two propositions from which the third is inferred are the *premises;* that which is inferred from them, the *conclusion.*

2. The *three* ideas or terms (two of which must be legitimately joined in each of the three propositions) are named respectively the *major*, the *minor*, and the *middle* term.

3. The *subject* of the conclusion is the minor term, and the *predicate* of the conclusion the major, as being generally of larger extension than the minor.

4. The major and minor terms are called the *extremes.*

5. The *middle term* is the third idea. It must occur in the same sense in each of the two premises, and form the connecting link between the major and minor terms.

6. The *major premise* is that proposition in which the *middle* is compared with the *major term;* the *minor premise*, that in which the *middle* is compared with the *minor term.* In other words, the *major premise* is that which contains the *predicate* of the conclusion; the *minor premise*, that which contains the *subject* of the conclusion.

Syllogisms are divided into different kinds, according to—(1) the nature of the conclusion; and (2) the position of the middle term.

1. According to the nature of the conclusion syllogisms are divided into universal-affirmative, universal-negative, particular-affirmative, and particular-negative; the conclusions in each of these cases being propositions of the classes denoted respectively by A, E, I, O.

In a universal-affirmative syllogism one idea is proved to *agree universally* with another, and may be *universally affirmed* (axiom 1) of it; as,

Every virtue conduces to happiness;
Patience is a virtue;
Therefore patience conduces to happiness.

In a universal-negative syllogism one idea is proved to *disagree universally* with another, and may therefore be *denied* (axiom 2) of it *universally;* as,

No human being is perfect;
All philosophers are human beings;
Therefore no philosophers are perfect.

In a particular-affirmative we have one idea stated to be wholly included in another, while part of both of these are affirmed to agree with each other; as,

Whatever furthers our ultimate good is really beneficial;
Some afflictions further our ultimate good;
Therefore some afflictions are beneficial.

In a particular-negative a universal exclusion is asserted and a partial exclusion is stated, then another partial exclusion from the first is inferred; as,

No afflictions arising from the operations of nature are morally degrading;
Some personal deformities are afflictions arising from the operations of nature;
Therefore some personal deformities are not disgraceful.

The following rules of pure categorical syllogisms are founded on the foregoing axioms:—

I. *The middle term must be distributed, or taken universally, once at least, in the premises,* i.e. *the middle term must be the subject of a universal, or the predicate of a negative proposition;* for if the middle term be taken twice particularly, then it may be taken for two different parts or kinds of the same universal idea, in which case the subject of the conclusion may be (for aught we know) compared with one of these parts and the predicate with another, so as to leave it undetermined (and perhaps undeterminable by us) whether the subject and predicate agree or disagree in their relation to that middle term—as in the following example:

[Some] steel is magnetic;
Saladin's sword was made of [some sort of] steel;
Therefore Saladin's sword was magnetic.

Here the middle term, "steel," is not distributed in either of the premises. The subject of the conclusion, "Saladin's sword," is stated in the minor premise to be "made of steel," *i.e.* of *some sort of* steel; and in the major premise it is affirmed not that all, but only that *some* steel is magnetic. The term *magnetic*, which is the predicate of the conclusion, may therefore really be affirmed of a different kind of steel from that which is affirmed of the subject, "Saladin's sword." The premises do not compel (or even enable) us to decide from them that Saladin's sword was magnetic.

When the subject of the conclusion refers to one part of the middle term and the predicate to another, the case is precisely similar to that of an *ambiguous* middle term—a case in which there are in reality two middle terms in actual *sense*, though but one in apparent expression, *i.e. sound*, as if we were to say:

Rulers are useful for keeping things straight;
Magistrates are *rulers;*
Therefore magistrates are useful for keeping things straight.

Here there are two middle terms. The word "rulers" in the major premise is used in a different sense from that which it bears in the minor. Therefore the subject and predicate of the conclusion are really compared with two different things. The case is precisely the same when the middle term is *particular* in both premises; in the one premise one thing is spoken of, and in the other another.

But if the middle term be distributed (*i.e.* taken universally) in *one* of the premises, this is sufficient, since if one *extreme* has been compared to a *part* of the middle term, and the other to the whole of it, both extremes must have been compared to the same; thus, if "*All* men are mortal," and if "*Kings* are (some) men," then it follows that we must think of *kings* whatever we must think of *all men;* and hence we infer that "Kings are mortal."

II. *The terms in the conclusion must never be taken more universally than they are in the premises;* or, more precisely, *No term must be distributed* (*i.e.* taken universally) *in the conclusion which was not distributed in one of the premises;* thus—

All crimes are sins;
Envy is not a crime;
Therefore envy is not a sin.

Here, in the major premise, the term *sin* is not distributed, being in this case the predicate of an affirmative proposition. In the conclusion, however, the same term is distributed, being the predicate of a negative. Now it is evident that universals cannot be inferred from particulars. Indeed, by distributing *sins* in the conclusion, a fourth term is introduced, for nothing has been said in the premises of "all sins."

III. *From two negative premises nothing can be concluded;* for in this case the middle term is merely pronounced to disagree with both extremes, and therefore it does not afford the means of comparing them with one another. Thus, from the premises—

No mathematician is a moral teacher;
Shakespeare is no mathematician—

nothing whatever can be inferred.

IV. *A negative conclusion cannot result from two affirmative premises.* This is obvious from the fact that two affirmative premises merely assert the agreement of *both* extremes with the middle term. Hence we can only infer the *agreement*, not the *disagreement*, of these extremes; and

this agreement can only be expressed by another *affirmative* proposition; as,

All men are rational,
All men are mortal,

can only yield at most the *affirmative* conclusion—"Some rational beings are mortal, or "Some mortals are rational beings."

V. *If one premise be negative, the conclusion must be negative;* for by the negative premise the middle term is pronounced to *disagree* with one of the extremes, while by the affirmative premise, it is declared to *agree* with the other. Hence, the two extremes themselves must disagree, and this disagreement can only be expressed by a *negative.* The syllogism never recognizes the correlation of premises unless they have each a common relation to a middle term, and not when they have no relation whatever.

VI. *If either of the premises be particular, the conclusion must be particular;* as,

All plants are organized;
Some of the mimoseæ are sensitive;
Therefore [not all but only] some organized things are sensitive.

VII. *From two particular premises nothing can be proved;* for if the conclusion be affirmative then the middle term cannot have been once distributed in the premises (as Rule I. requires), and if it be negative the major term must be understood as distributed in the conclusion, while it has not been distributed in the premises. This Rule II. declares invalid.

The *mood* of a syllogism signifies the formal arrangement of the propositions according to their quantity and quality, not of the conclusion only, but of each of the three propositions of which the syllogism consists. The quantity and quality of propositions are denoted by the letters A, E, I, O. In *quantity* a proposition is either universal or particular; in *quality*, either affirmative or negative; *e.g.*

Symbols of quantity and quality.	Examples.
A (Universal-affirmative), .	All planets are inhabited.
E (Universal-negative), . .	No planets are inhabited.
I (Particular-affirmative), .	Some planets are inhabited.
O (Particular-negative), . .	Some planets are not inhabited.

In designating the mood of a syllogism those vowel letters are employed which indicate the quantity and quality of each of its three propositions in the order in which they stand. Thus in the following syllogism—

(A), ...	All animals possess senses;
(I), ...	Some animals are dogs; therefore
(I), ...	Some dogs possess senses,

the propositions are respectively denoted by the letters A, I, I. These letters, therefore, denote the *mood* of the syllogism. So in the following example:—

(E), ...	No envious person is happy;
(I), ...	Some learned men are envious; therefore
(O), ...	Some learned men are not happy.

Here the major premise is E (universal-negative); the minor, I (particular-affirmative); the conclusion, O (particular-negative); therefore the *mood* of the syllogism is E, I, O.

Syllogisms are also distinguished from one another according to their figure. The figure of a syllogism is determined by the situation of the middle term with respect to the major and minor terms, which, as previously defined, are the predicate and subject of the conclusion. This admits of four arrangements, termed respectively the first, second, third, and fourth figures, as follows:—

First figure—When the middle term is made the subject of the major premise and the predicate of the minor.

Second figure—When the middle term is the predicate of both premises.

Third figure—When the middle term is the subject of both premises.

Fourth figure—When the middle term is the predicate of the major premise and the subject of the minor.

The following scheme of the different figures, in which M symbolizes major term, N minor, and x middle, will show at a glance the disposition of the middle term in each:—

1st fig.		2nd fig.		3rd fig.		4th fig.
x, M	...	M, x,	...	x, M,	...	M, x,
N, x,	...	N, x,	...	x, N,	...	x, N,
N, M,	...	N, M.	...	N, M.	...	N, M.

The first of these figures is the simplest and most natural; it is that alone to which the dictum of Aristotle can be directly applied.

The fourth figure is exactly the reverse of the first; it is the most unnatural and awkward of all, and on that account is rarely used in general argument.

Neither the mood alone nor the figure alone determines the exact form of the syllogism. Thus, in the first figure we may have syllogisms of different forms, *e.g.*,

(1)		(2)		(3)
All x is M;	...	All x is M;	...	No x is M;
All N is x;	...	Some N is x;	...	Some N is x;
therefore,	...	therefore,	...	therefore,
All N is M.	...	Some N is M.	...	Some N is not M.

Other variations in quantity and quality occur not only in the first, but in every other figure. Now it will be seen that, in the first example, both the premises and the conclusion are universal-affirmative; in the second example the major premise is universal-affirmative, the minor premise and conclusion, particular-affirmative; in the third example the major premise is universal-negative, the minor particular-affirmative, the conclusion particular-negative. The first is, therefore, of the mood A, A, A; the second, of the mood A, I, I; the third of the mood E, I, O; and all three are called syllogisms of the first figure.

To determine the exact form of a syllogism, therefore, we require to know both the figure and mood. This will be sufficient for the purpose. Let it be proposed, for example, to construct a syllogism in the third figure, mood A, A, I; then, assuming the symbols of the three terms as before, we shall have the following form:—

(A) All x is M;
(A) All x is N;
therefore,
(I) Some N is M.
} Syllogism in 3rd figure, mood A, A, I.

Or, substituting significant terms, *precious* for the major term M; *mineral* for the minor, N; and *gold* for the middle, x, we have the following syllogism:—

All gold is precious;
All gold is (some or a) mineral;
Therefore some mineral is precious.

Can true conclusions be reached in the three previous forms by using the symbols similarly? Try.

CHEMISTRY.—CHAPTER XI.

QUANTIVALENCE—VARIATIONS OF QUANTIVALENCE—AMMONIACAL GAS—MANGANESE ATOM—LAW OF VARIATION OF QUANTIVALENCE—GRAPHIC SYMBOLS—METATHESIS—ALKALIES AND ACIDS—INFLUENCE OF THE RADICAL HYDRATES.

When the compounds of the elements in the annexed table are examined, looking at the first line of symbols it will be seen that there is a remarkable relation in which the atoms stand to each other:—

HCl	H_2O	H_3N	H_4C		
$NaCl$	$HgCl_2$	$SbCl_3$	CCl_4	PCl_5	CrF_6
H^2O	HgO	$NOCl$	CO_2	$POCl_3$	CrO_3
			$COCl_2$		CrO_2Cl_2
			COH_2		

In a molecule of hydrochloric-acid gas (HCl) one atom of chlorine is united to one atom of hydrogen (H—Cl). In the molecule of water (H_2O) one atom of oxygen is united to two of hydrogen (H–O–H). In the molecule of am-

monia gas (NH_3) one atom of nitrogen is united to three atoms of hydrogen, $\begin{array}{c}H\\|\\H-N\\|\\H\end{array}$, and in the molecule of marsh gas (CH_4) the atom of carbon is united to four atoms of hydrogen, $\begin{array}{c}H\\|\\H-C-H\\|\\H\end{array}$. It thus appears that the atoms of chlorine, oxygen, nitrogen, and carbon have different powers of combination, uniting respectively with one, two, three, and four atoms of hydrogen. That this combining power is the result of a definite quality of the several atoms is further illustrated by reference to the second line of symbols. Thus the atoms of sodium (Na), mercury (Hg), antimony (Sb), carbon (C), and phosphorus (P) unite respectively with one, two, three, four, and five atoms of chlorine. It will also be observed on comparing the two lines of symbols, that the atom of chlorine which combines with one atom of hydrogen combines also with one atom of sodium, and that the atom of carbon which combines with four atoms of hydrogen combines also with four atoms of chlorine. On the third line it will be seen that the atom of mercury which combines with two atoms of chlorine combines with only one atom of oxygen; and that the atom of carbon which combines with either four atoms of chlorine, or four atoms of hydrogen, combines with two atoms of oxygen. When these combinations are compared with those first noticed, where the atom of oxygen combined with two atoms of hydrogen and the atom of chlorine with but one, it is evident that these relations are not accidental, but follow some atomic system.

The explanation which the modern system of chemistry affords is based upon the assumption that each of the elementary atoms has a certain definite number of *bonds*, or what may be termed, to express the theory, *poles*, somewhat analogous to the magnetic poles of a magnet. On this supposition the relation between the atoms at once becomes clear and intelligible. The hydrogen, sodium, and chlorine atoms have only one *pole*, and hence in combining with each other they can only unite in *pairs*. The oxygen atom has two poles, and can therefore combine with two hydrogen atoms, one at each pole. The mercury atom has also two poles, and in a similar manner takes two atoms of chlorine; but it can only combine with a single atom of oxygen, for the two poles of the one exactly satisfy the two poles of the other. Further, the atom of carbon has four poles, which may take up either four atoms of hydrogen or four atoms of chlorine, or two atoms of oxygen, or one atom of oxygen and two of chlorine, or one atom of oxygen and two of hydrogen. Again, the atom of phosphorus has five poles, and holds five atoms of chlorine, or three atoms of chlorine and one of oxygen. Again, the chromium atom binds six atoms of fluorine, or three of oxygen, or two of oxygen and two of chlorine. This quality of the atoms, which has been familiarly represented by the conception of bonds or poles, is termed in modern chemistry *quantivalence*, and the Latin terms *univalent*, *bivalent*, *trivalent*, *quadrivalent*, *quinquivalent*, *sexivalent*, &c., are used to designate the atoms which have one, two, three, four, five, six, &c., bonds or poles respectively.

$$\begin{array}{cccc}
H- & -O- & -\overset{|}{N}- & -\overset{|}{\underset{|}{C}}- \\[6pt]
Cl- & -S- & -\overset{|}{P}- & -\overset{|}{\underset{|}{Si}}- \\[6pt]
F- & -Ca- & -\overset{|}{Sb}- & -\overset{|}{\underset{|}{Sn}}- \\[6pt]
K- & -Mq- & -\overset{|}{As}- & -\overset{|}{\underset{|}{Ti}}- \\[6pt]
Na- & -Hq- & -\overset{|}{B}- & -\overset{|}{\underset{|}{Pt}}- \\[6pt]
Aq- & -Zn- & -\overset{|}{Au}- & -\overset{|}{\underset{|}{Zr}}-
\end{array}$$

The above diagram shows a few of the more important elementary atoms classified according to their *quantivalence*, and it also indicates how by a slight addition to the symbolic notation the number of poles or combining power of the atom may be represented. In writing symbols of molecules a dash between two letters indicates, therefore, the union of two poles or bonds, and one pole or bond on each atom is then understood to be closed. Two dashes will indicate that two poles on each atom are closed, and so on with a larger number. This will be clear from the annexed diagram, which partly repeats the first diagram of quantivalence, except that the bonds or poles are shown of each atom.

$$\begin{array}{cccc}
H-H & H-O-H & \begin{array}{c}H\\|\\H-N-H\end{array} & \begin{array}{c}H\\|\\H-C-H\\|\\H\end{array} \\[12pt]
H-Cl & Cl-Hg-Cl & \begin{array}{c}Cl\\|\\Cl-Sb-Cl\end{array} & \begin{array}{c}Cl\\|\\Cl-C-Cl\\|\\Cl\end{array} \\[12pt]
 & Hg=O & Cl-N=O & O=C=O
\end{array}$$

This symbol of quantivalence implies that the molecules have a definite structure. For instance, in the molecule CH_4 it seems natural that the carbon atom should be united at four distinct points with the four hydrogen atoms, $\begin{array}{c}H\\|\\H-C-H\\|\\H\end{array}$. There is not an indiscriminate grouping of the five atoms, but a presumed definite arrangement, with the carbon atom at the centre of the system. In the molecule CCl_4 there is the same structure as CH_4, determined as before by the quadrivalence of the nucleus. Examining the molecule CO_2, an equally definite structure is found, the four poles of the same nucleus being satisfied by two bivalent atoms of oxygen. Intermediate in structure between these last two molecules are the molecule of phosgene gas ($COCl_2$), and the molecule of formic aldehyde (COH_2). When the symbols of these molecules are examined they seem to indicate a limitation to the ideal form of structure described. But the theory is sufficient to show that in the molecule CCl_4, for example, the four chlorine atoms are united to the carbon-nucleus by four different poles or bonds, and in the molecule CO_2 the two oxygen atoms are united to the same nucleus, each by two poles. Beyond this nothing further can be said, and the symbols may be grouped round the nucleus of the molecule in any way most convenient, provided only that they satisfy the condition of quantivalence. It is therefore immaterial whether the symbol $HgCl_2$ is written

$Cl-Hg-Cl$, or $Hg<^{Cl}_{Cl}$; or the symbol $COCl_2$ is written $\begin{array}{c}Cl-C-Cl\\\|\\O\end{array}$, or $\begin{array}{c}Cl\\|\\O=C\\|\\Cl\end{array}$: either way they have the same interpretation.

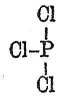
The quantivalence of the atoms is, however, by no means an invariable quality, but any change in the quantivalence of an atom is accompanied by a change in all its chemical relations, and the change is restricted by definite limits. Thus, when ammonia gas (NH_3) is united with hydrochloric acid (HCl), there is a change in the quantivalence of the nitrogen atom from three to five. This will be seen by comparing the symbol of the first factor with the symbol of the sole product of the reaction:—

Ammonia Gas.	Ammonic Chloride.
$\begin{array}{c}H\\|\\H-N\\|\\H\end{array}$	$\begin{array}{c}H\\|\\{}^{H}_{H}>N-Cl\\|\\H\end{array}$

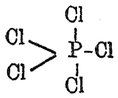
From ammonia gas (NH_3) a large class of compounds are derived, in all of which nitrogen is trivalent, and from ammonic chloride (NH_4Cl) another class of compounds, in which nitrogen is quinquivalent; but although both classes contain the same atom as a nucleus, they differ as widely from each

other as if they were the resultant of different elements. Phosphorus exhibits similar conditions in the two well-marked chlorides PCl_3 and PCl_5.

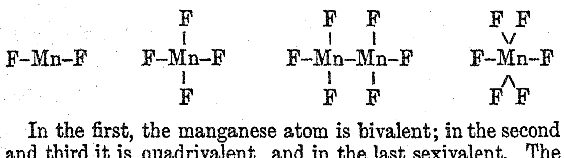
Phosphorous Chloride.



Phosphoric Chloride.



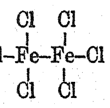
Manganese, however, affords perhaps the most striking instance of the variation of quantivalence in its atom. Manganese forms four compounds with fluorine, the molecules of which may probably have the atomic constitution represented by the following symbols:—



In the first, the manganese atom is bivalent; in the second and third it is quadrivalent, and in the last sexivalent. The third molecule contains two quadrivalent atoms of manganese united by a single pole, and the two together form a complex nucleus which is sexivalent. Here, therefore, is a distinct class of compounds, corresponding to the four conditions of the nucleus, and in which the chemical relation of the bivalent and those of the sexivalent atoms of manganese is almost as wide as that between the atom of zinc and the atom of sulphur.

The compounds of iron likewise illustrate the effect produced by a variation of quantivalence. The two classes of compounds are the ferrous and the ferric compounds: the first consists of molecules, of which the nucleus is a bivalent atom of iron; the molecules of the second class are grouped around a nucleus consisting of two quadrivalent atoms, united as shown in the third molecular grouping of manganese and fluorine.

The symbols of ferrous and ferric chloride are:—

$FeCl_2$ or Cl–Fe–Cl, and Fe_2Cl_6 or 

Among several of the most important of the chemical elements the condition of quantivalence appears to be invariable. This is the case with hydrogen, and it is also true of the alkaline metals, lithium, sodium, potassium, cæsium, and rubidium; and it is likewise so with silver, all elements whose atoms are univalent. The same holds good with the trivalent element boron. Again oxygen is always bivalent, and so are the metallic radicals of the alkaline earths, calcium, barium, strontium, and magnesium; and the metallic elements, lead, zinc, and cadmium. Aluminium, titanium, silicon, and carbon are always quadrivalent, although in the single instance of the molecule CO the carbon atom appears to be bivalent.

Although the variations in quantivalence are confined to a limited number of the elementary atoms, these variations seem to follow a definite law, which may point to an explanation of their cause. Thus the successive degrees of quantivalence in gold and phosphorus follow the order of the odd numbers,

AuCl	$AuCl_3$	
	PCl_3	PCl_5,

while those of manganese follow the order of the even numbers,

MnF_2 MnF_4 MnF_6.

What is true of these atoms is, in general, true of the atoms of all those elements which have several degrees of quantivalence; that is, at each successive step the quantivalence increases by two bonds or poles, and never by a single bond or pole.

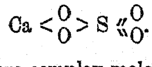
Atoms with odd degrees of quantivalence have been termed *perissads*, and those with even degress *artiads;* there are, however, important exceptions to the general principle. This theory of quantivalence constitutes one of the distinctive features in which the new system of chemistry differs from the old, and the recognition of the fact that a definite quantivalence is an inherent characteristic of each elementary atom has been one of the chief causes which has led to the foundation of the science on the new basis. In the old system of chemistry the reason why the elementary substances united in a compound was scarcely ever considered; but in the new chemistry the manner in which the atoms are grouped together in the molecule is an all-important question. Every molecule is a unit in which all the atoms are united by their several poles, and the exact manner in which the molecular structure is built up now forms an important subject of investigation.

The qualities and chemical relations of a compound are determined fully as much by the structure of its molecules as by the nature of the atoms of which the molecule consists.

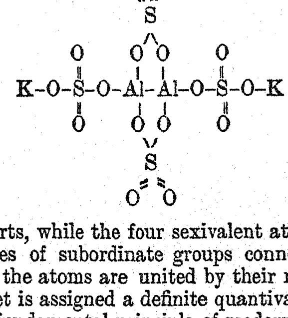
Formerly it was supposed that the qualities of an acid or an alkali were simply the characteristics of the compounds of certain elements with oxygen. Now it is shown that they are the result of a definite molecular structure, and are only slightly modified by the characteristics of the individual atoms which may happen to be the nucleus of the molecule. Molecular structure is therefore the basis of the new chemistry, and it is evident that with univalent atoms solely, only molecules consisting of two atoms can be formed, such as Na–Cl, or H–Br. When bivalent atoms are introduced, the structure of the molecule becomes more complex, as in H – O – H, or K – O – Cl. With several bivalent atoms molecules can be formed in which the atoms follow in a chain, sometimes of considerable extent, as

Calcic Hydrate.		Triplumbic Hydrate.
H–O–Ca–O–H,	or	H–O–Pb–O–Pb–O–Pb–O–H.

And with atoms of higher quantivalence groups of exceeding complexity arise, of which the multivalent atom, or that which has a high degree of quantivalence, is the nucleus, and serves to bind together the parts of the molecule. As an example, the molecule of calcic sulphate has a complex constitution, and the sexivalent atom of sulphur forms the nucleus of the group, and holds the atoms together,



Again, in the still more complex molecule of alum the double atom of aluminium is the nucleus of the group, and unites



the several parts, while the four sexivalent atoms of sulphur are the centres of subordinate groups connected with this nucleus. All the atoms are united by their respective poles, and to each set is assigned a definite quantivalence.

This is the fundamental principle of modern chemistry, and it may be shortly stated as follows:—*The integrity of every complex molecule depends on the multivalence of one or more of its atoms, and no such molecule can exist unless its parts are united together by the atomic poles or bonds.* The molecular structure of bodies is inferred chiefly from the reactions of which they are susceptible, or by which they are formed.

Metathesis consists in the interchange of atoms or groups of atoms between two molecules, and implies that the structure of these molecules is not otherwise altered. Such an interchange involves the breaking up of two sets of molecules, and the production of two new sets of molecules. Thus the products of the reaction of sodium on water are hydrogen gas and caustic soda. The molecular constitution of these factors are known. The symbol of a molecule of sodium is Na–Na, and that of water is H–O–H. The molecule of hydrogen

gas has the symbol H–H. As regards the molecule of caustic soda, chemical analysis shows that it consists of sodium, oxygen, and hydrogen in the combining weights of the several atoms. Analysis therefore shows that the molecule of caustic soda contains an equal number of atoms of all three of its elementary constituents, but does not determine whether its symbol is NaOH or $Na_2O_2H_2$, or any other simple multiple of these letters. It is here that the principles of quantivalence step in and determine the value of the symbol; for as H and Na are univalent atoms, the molecule of oxygen can only hold two such atoms, therefore the symbol must be Na–O–H, and can be nothing else. The symbols of the factors and the products of the reaction are therefore:—

Sodium.	Water.		Caustic Soda.	Hydrogen.
Na–Na	H–O–H	=	Na–O–H	H–H

and as there are two atoms of Na in the molecule of the metal, two molecules of Na–O–H must have been formed; and as then there will be four atoms of hydrogen among the products, there will have been two molecules of water employed in the factors, and the reaction therefore becomes

$$\text{Na–Na} + 2\text{H–O–H} = 2\text{Na–O–H} + \text{H–H}.$$

If now the reaction is represented by graphic symbols, the nature of the change will be more clearly presented:—

$$\begin{array}{c} \text{H–O–H} \\ \text{H–O–H} \end{array} + \begin{array}{c} \text{Na} \\ | \\ \text{Na} \end{array} = \begin{array}{c} \text{Na–O–H} \\ \text{Na–O–H} \end{array} + \begin{array}{c} \text{H} \\ | \\ \text{H} \end{array}$$

Thus the two atoms of sodium have changed place each with an atom of hydrogen in the molecule of water, and the displaced atoms of hydrogen have taken the place of the atoms of sodium. In this chemical reaction the new molecules have precisely the same structure as the old, differing only from them in the substitution of Na for H, or the reverse. This reaction is a simple illustration of metathesis.

Caustic soda, one of the products of the reaction, belongs to a class of substances termed alkalies; there is another class of compounds which bear a striking antithesis to those of the alkalies—the acids. The alkalies change the colour of paper dyed with turmeric or litmus; the acids restore the colour again. Thus, when litmus paper is dipped into a solution of caustic soda the colour of the paper is at once changed, and on dipping it into a solution of hydrochloric acid (HCl) the former colour is rapidly restored. The acid at once undoes the effect of the alkali, and if the acid solution be added by degrees to the alkaline solution the alkaline reaction becomes feebler and feebler until at last it disappears. And again, if the alkaline solution be in like manner added to the acid solution the acid qualities disappear, or the acid and alkali have neutralized each other, and in so doing have formed chloride of sodium (common salt) and water.

The chemical reaction may be symbolized as follows:—

Caustic Soda.		Hydrochloric Acid.		Water.		Chloride of Sodium.
Na—O—H	+	HCl	=	H—O—H	+	Na—Cl

Showing that the reaction has consisted in the simple substitution of Na for H in the molecule HCl, and the reproduction of a molecule of water; that is, the metallic atom of the alkaline molecule changes place with the hydrogen atom of the acid molecule. The neutralization of an acid by an alkali is therefore a simple metathetical reaction. As a further example to illustrate this important principle of metathesis, take potassium and water, the reaction of which is hydrogen gas and potash or potassic hydrate, the chemical symbols being—

Potassium.		Water.		Hydrogen Gas.		Potassic Hydrate.
K—K	+	2H—O—H	=	H—H	+	2K—O—H

Here likewise the atoms of potassium take the place each of a hydrogen atom in one of the molecules of water. Again, taking the case of potassic hydrate and nitric acid as a further illustration:—

Potassic Hydrate.		Nitric Acid.		Water.		Potassic Nitrate.
K—O—H	+	$H—NO_3$	=	H—O—H	+	$K—NO_3$

Here the reaction consists simply in an interchange between the hydrogen atom of the acid and the metallic atom of the alkali, and is precisely similar to the reaction between the sodic hydrate and hydrochloric acid. These chemical reactions, which might be multiplied almost indefinitely, establish the following important principles:—First, an *alkali* is a substance whose molecules have a definite structure, and differ from the molecules of water only in having a metallic atom in place of one of the hydrogen atoms of the water molecule. Second, an *acid* is a substance whose molecules contain at least one atom of hydrogen, which is readily replaced by the metallic atom of the alkali when the two substances are brought together. Acids and alkalies are therefore considered as belonging to the same class of compounds, and caustic potash and nitric acid are simply the opposite extremes of a series of bodies in which all the intermediate gradations are fully represented. This class of chemical substances are termed *hydrates*, and the two extremes of this class are distinguished as alkaline or basic and acid hydrates respectively. Acids and alkalies exhibit the same general molecular structure, and the susceptibility to the replacement of the hydrogen atom or atoms, which all these compounds contain, depends upon the molecular structure, and the differences between acids and alkalies on the nature of the radical, or the atom, or group of atoms which determines the character of the molecule. The simple radicals, as they appear in the elementary substances, may be divided into two classes, the metals and the non-metals or metalloids, and radicals of opposite natures combine most readily together, two metals or two metalloids showing but little affinity for each other.

SHORTHAND.—CHAPTER VII.

HALF-SIZED CONSONANTS—*W* AND *Y* SERIES OF DIPHTHONGS—VOCALIZATION OF THE *PL* AND *PR* SERIES—PREFIX *CON* OR *COM* AND AFFIX *ING*—GRAMMALOGUES.

In the preceding chapter we illustrated the use of half-sized consonants as adapted to the simple, straight, and curved consonants, and their use in indicating the past tense of the regular verbs. The shortening principle therein explained also applies to the hooked letters; thus, *prate*, *plate*. A consonant with circle *s* or hook prefixed or affixed, or even with the circle *s* at both ends, may be shortened; as, *pants*, *tufts*, *spots*, *splints*, *sprites*. This extended adaptation of the *halving* principle needs careful handling and attentive study.

When a stroke terminating with the *n* hook is shortened, the *n* must be read before the *t* or *d* which has been added, as *pain*, *paint*, *pains*, *paints*, *inclined*.

The following order must be uniformly observed in the consonantal elements of all words in which the *halving* principle is applied.

(1) The initial circle or loop is to be read first. (2) Then the stroke letter (with or without the initial hook). (3) Next the final hook. (4) Afterwards the *t* or *d* added by halving. (5) And lastly, the circle *s*, or loop *st*, thus:—

1 2 4 5	1 2 3 4 5	1 2 3 4 5	2 3 4 5
s..p..t..s;	st..d..n..t..s;	s..pl..n..t..s;	t..f..t..s.
spots.	*students.*	*supplants.*	*tufts.*

W AND *Y* SERIES OF DIPHTHONGS.

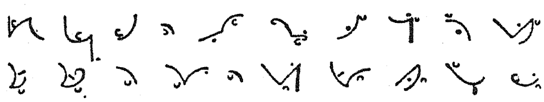
We now come to a combination of sounds generally called the *w* and *y* series of diphthongs. The part they play in the representation of words is not an unimportant one. Though we know that many self-taught students find some difficulty in clearly understanding and accurately employing these diphthongs, yet we hope our students will see that we have spared no pains to make it simple. It must first be noticed that this series of characters is formed from the vowels the student has already learned, with the *wah* and *yah* added to them. It is strongly recommended that the student should learn these diphthongs in the same

way as he was advised to acquire facility in the use of the vowels; namely, by repeating them before or after the consonant with which they are connected, as—

W Series:—Wah | weh | wee | waw | woh | woo |
Y Series:—Yah | yeh | yee | yaw | yoh | yoo |

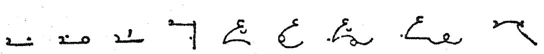
The shorthand signs are written heavy to represent long sounds, and light to represent short sounds in precisely the same way in this respect as the simple vowels.

The next exercise illustrates the use of these diphthongs *wah* and *yah* in their twofold use as signs of both long and short sounds.

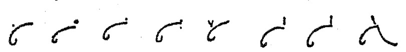


The second of the two *w* signs ( ) may be employed before the letters *k*, *g*, and *m*, instead of the full sign , thus *wake*, *week*. The long and short *waw* and *wō* may be joined to *k*, *g*, and *m*, upward *r*, and a few other letters when the joining is found to be convenient, in order to represent *w* and the vowel in conjunction with it; as, *walk*, *war*, *walker*. A slightly varied form of added to *l* makes the sign of the double consonant *wl*.

The following exercise serves to show the use of the joined diphthong.



Upward *wl.*

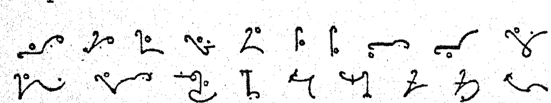


It may give some help to the learner in recollecting the correct sign for the *wah* and *yah* series if it is remembered that the figure of the mouth in pronouncing *yah*, *yeh*, &c., is , that is, horizontal; therefore the signs are and , and in the *wah*, *weh*, &c., the position of the mouth approaches the vertical ( ) , therefore the signs are and

VOCALIZATION OF THE *PL* AND *PR* SERIES.

In such words as *tell*, *term*, a vowel requires to be sounded between the *tr* and *tl*. Although words that need the method of vocalization, shown below, seldom occur, the need has been provided for by writing a small circle BEFORE the consonant for a long vowel, and AFTER the consonant for a short vowel, as *chairman*, *German*. In some cases, where the position of the consonants make it inconvenient to observe this rule, the circle may be written on either side. The dash or stroke vowels *aw*, *oh*, *oo* may be written through the consonant, as in *torment*, *course*, *school*.

The student should now read and practise the undergiven examples of vocalization :—



PREFIX *CON* OR *COM* AND AFFIX *ING*.

The prefix *con* or *com*, which is of very frequent occurrence, is represented by a light dot at the commencement of a word; thus, *contest*, *combine*.

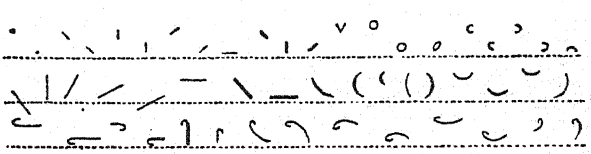
The affix *ing* is indicated by a light dot at the end of a word; thus, *eating: ings* is shown by a short stroke; as *turnings;* but when it is more convenient we write ; as *rising*, *facings*. This final dot is however not used in monosyllables like *king*, which is written The following words will illustrate the application of the use of the prefix *con* and affix *ing* :— *lodgings*, *completing*, *comforting*, *compounding*, *buildings*, *consequent*.

GRAMMALOGUES OR LETTER WORDS.

The pupil may now proceed to learn the following list of grammalogues—*i.e.* signs used to represent complete words of frequent recurrence. It will be found a good plan to learn them by writing a dozen or so at a time, or a column at a time, and then endeavouring to construct sentences in which they occur, and afterwards to revise them. Words marked (1) are written above the line, words marked (3) through the line, the others rest on the line.

a, an (1)	first	near	the$^{ir}_{re}$
all (1)	for	nor (1)	thing
and (1 up)	from	not (1)	think
are (up)	give-n	of (1)	to
as, has (1)	great	on (1)	told
be	have	our (3)	was
but	he	put (3)	what (1)
call (1)	I (1)	shall	when
can (1)	in (1)	short (1)	which
cannot (1)	is, his	should (up)	who
care	it	that (1)	with (1)
could	mere	the	would
dear	more (1)	them	you

The following exercise embraces all the above logograms or word-letters. This the student ought carefully to read and copy, and in writing them he should place the grammalogue in longhand after each sign.



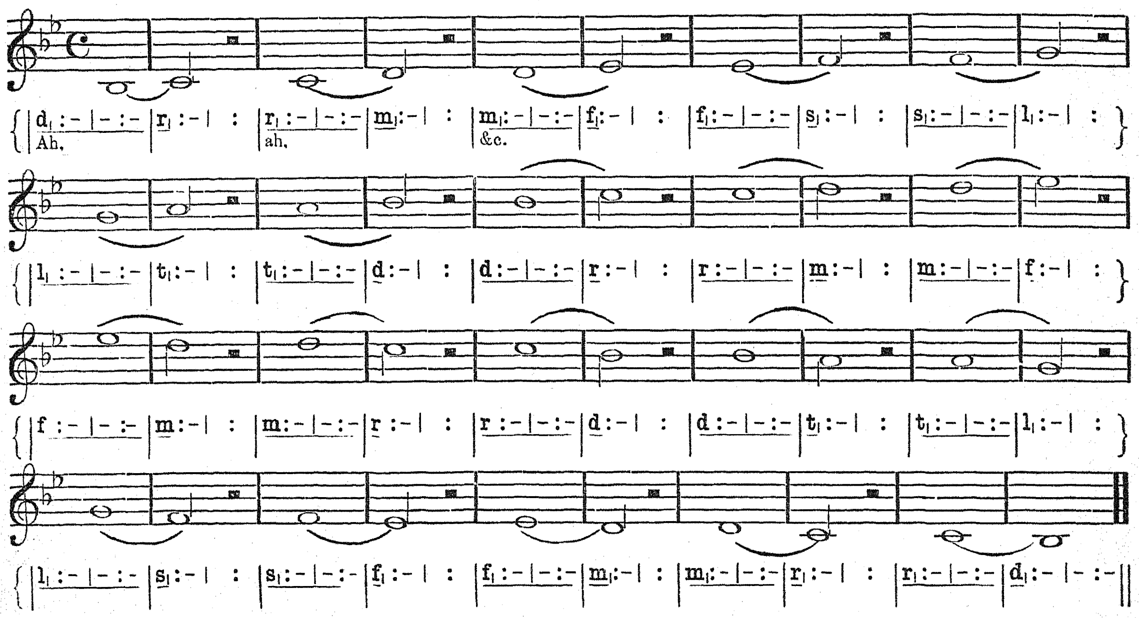
MUSIC.—CHAPTER VII.

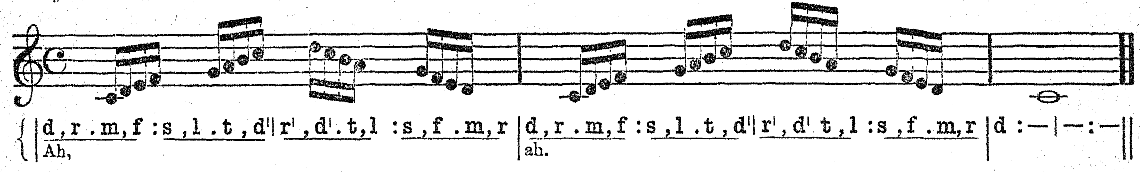
VOICE-FORMING STUDIES—TIME EXERCISES—ST. AMBROSE, ST. GREGORY—THE ECCLESIASTICAL MODES—MODERN MINOR—ILLUSTRATIVE EXAMPLES.

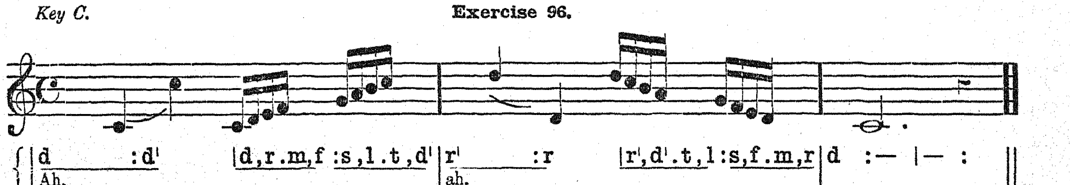
THE value of voice-forming exercises and studies is now, it is hoped, so appreciated by the student that no apology need be made for beginning this chapter with a few of those the utility of which has been tested. It will be advisable to read over again carefully what has already been said on this subject (Chaps. III., IV., and V.) In Exercise 94, with long or sustained notes, breaths should be taken at the rests. In those that follow, the scale-form is chiefly employed to promote flexibility of voice and increase of vocal power. The notes on

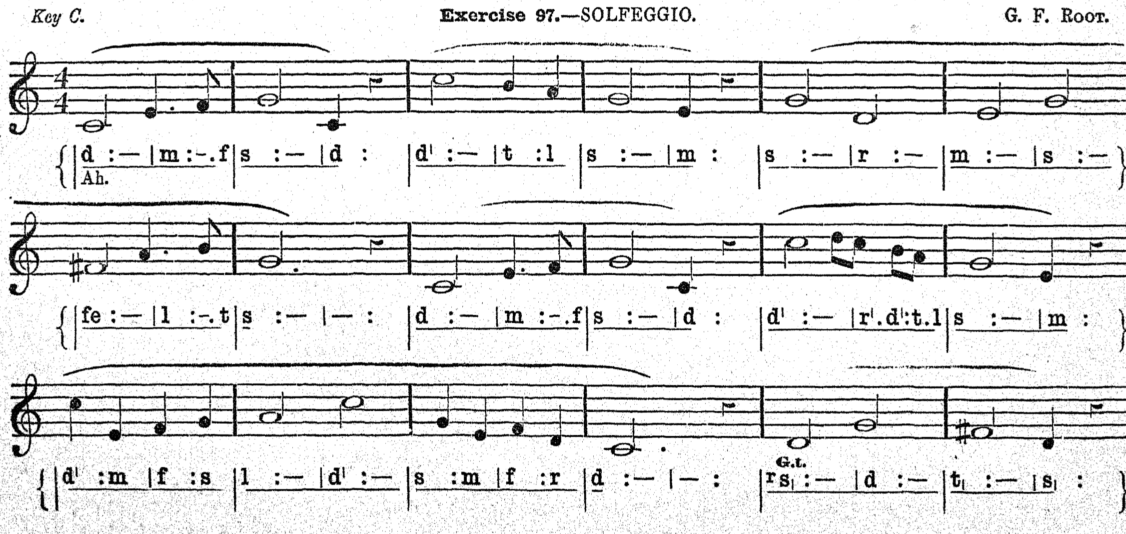
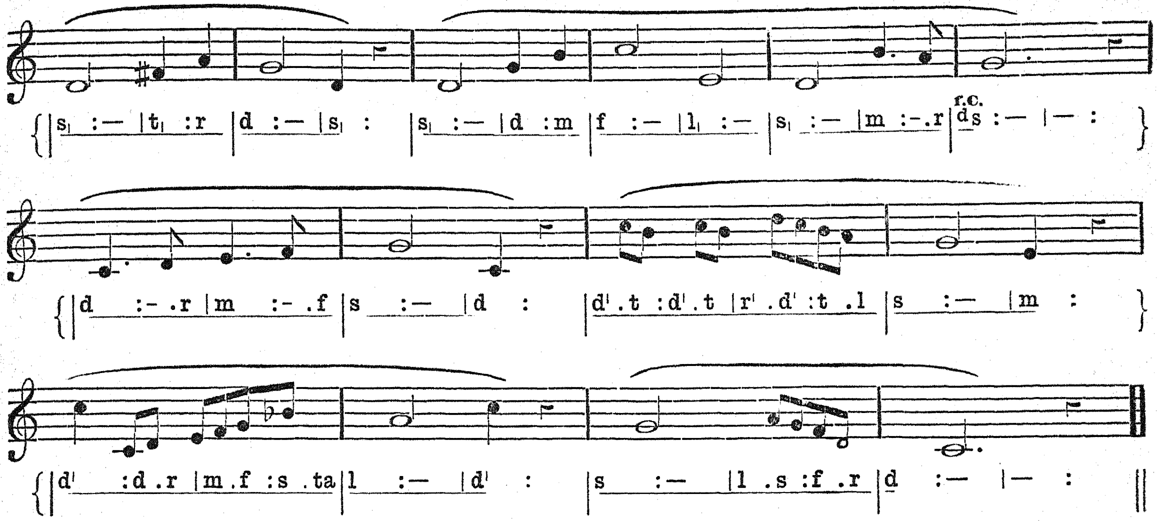
these should be sung *legato*, or connectedly, and at first very slowly. Like a string of pearls, the notes should touch each other and yet be quite distinct. Exercise 97 is called a *solfeggio*, a species of study which is largely used by the best teachers; the phrases or portions into which it is divisible are shown by the curved lines above the staff. Breath should be taken after each of these phrases, and each separate part should, as a rule, be begun and ended softly, with a slight increase of power (*crescendo*) in the middle. This is called "the art of phrasing."

Key B♭. (Should be sung on C and D♭ also). **Exercise 94.**

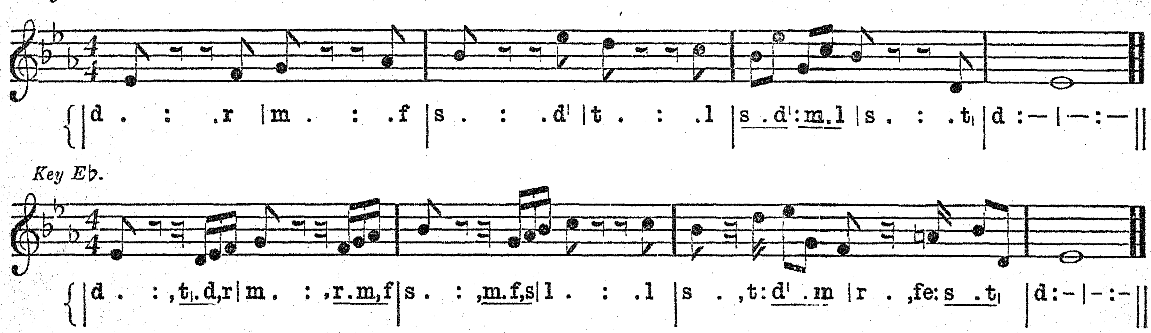


Key C. **Exercise 95.**

Key C. **Exercise 96.**



Key C. **Exercise 97.—SOLFEGGIO.** G. F. Root.

Time exercises should now include rests of half and quarter beats (pulses). Let the following be sung, first on one tone, in strict time, to the syllable "la," and afterwards in time and tune:—

Key E♭. **Time Exercises.** J. S.



Hitherto the attention of the student has been so directed that he might obtain a knowledge of the scale and the method in which it is chiefly used in the music of the present day. It is now, however, requisite to explain that there is another mode or manner of employing the scale, secondary certainly to that already considered, but largely drawn upon by the very best composers, who, through the use of it, produce some of their finest effects. That this department may be thoroughly understood, it is necessary here to give a brief historical sketch of its origin and the process by which it has reached its present position.

Towards the end of the fourth century Ambrose, bishop of Milan, commonly called St. Ambrose—a man destined to have a mighty influence on "the music of the future"—rose to eminence and power in the Christian church. "The condition and prospects of the arts," says Hullah, "were at this time so low that, but for the universal instinct which suggests song as a means of prayer and praise, music might have gone out of the world altogether." The special work of Ambrose consisted in selecting from the infinity of signs and symbols used by the Greeks in their musical notation a few simple scales suitable for use among a rude people. These Ambrosian scales were, it is said, four in number, and consisted in each case of only four notes, forming what is called a *tetrachord*. Authorities agree in saying that great success attended the efforts then put forth. St. Ambrose has therefore the high honour of standing out in history as the man who laid the strong foundation upon which our present elaborate musical system is erected.

After the death of Ambrose, music fell very much into the condition in which it was before his time. Men and women sung nearly as nature dictated, and so continued to do till Pope Gregory appeared, fully two hundred years afterwards. This great man and renowned musician was born in Rome about A.D. 550. His name is intimately associated with the history of this country and the progress of Christianity. Turning his attention to music, Gregory gathered up the fragments left by Ambrose, his musical predecessor, and greatly enlarged the scales both in number and extent or compass. He demonstrated that a new tetrachord could be begun where the first ended, and so made a scale of eight notes instead of four—the eighth being a replicate or octave of the first. The note on which the scale began and ended was called "the final," or as we would now say, the key-note; and thus it came to pass that upon every note of the scale, as we know it, was built a Gregorian scale, now termed variously a "Gregorian tone" or "mode." He found, moreover, that by beginning a fourth below the final (or chief tone) of any of these modes, he could make a sort of an attendant scale to each. Thus if the original, or *authentic*, as it was termed, went from C to C' (Doh to Doh') it would have as its attendant (called its *plagal*) a scale running from G_1 to G (Soh_1 to Soh). Following a custom begun by the Greeks, these separate scales were named after different provinces of the Grecian empire. The following is a complete table of the Gregorian tones or modes, with the names and positions both of the authentic and the plagal (Gr. πλαγος, oblique). The latter is always distinguished by the prefix "hypo." From this table it will be seen that in these early times there was no idea entertained of *one* key-tone as we understand it. Thus the modal tone or "final," on which the scale was built, was what would now be called the tonic or principal note. In most

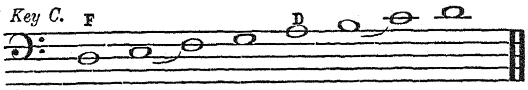
cases the fifth above this final was dominant, but in some modes this required to be altered, owing to the position of the semitones. In the table the dominant is marked by the letter D, and the final by the letter F.

ECCLESIASTICAL MODES.

AUTHENTIC MODES.

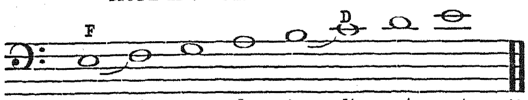
Mode I.—The Dorian Mode.

Key C.



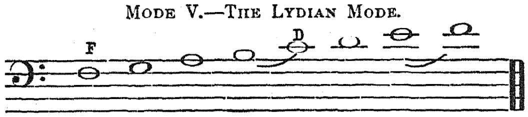
r m f s l t d^1 r^1

Mode III.—The Phrygian Mode.



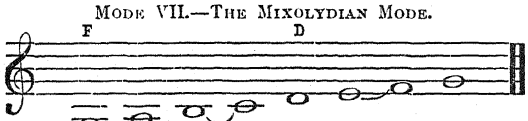
m f s l t d^1 r^1 m^1

Mode V.—The Lydian Mode.



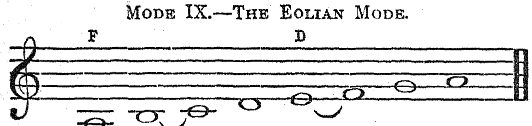
f s l t d^1 r^1 m^1 f^1

Mode VII.—The Mixolydian Mode.



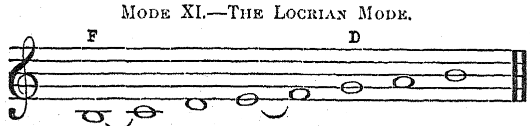
s_1 l_1 t_1 d r m f s

Mode IX.—The Eolian Mode.



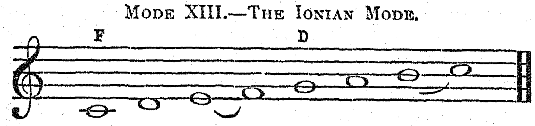
l_1 t_1 d r m f s l

Mode XI.—The Locrian Mode.



t_1 d r m f s l t

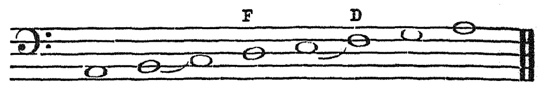
Mode XIII.—The Ionian Mode.



d r m f s l t d^1

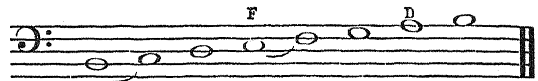
PLAGAL MODES.

Mode II.—The Hypodorian Mode.



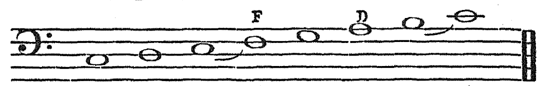
l_1 t_1 d r m f s l

Mode IV.—The Hypophrygian Mode.



t_1 d r m f s l t

Mode VI.—The Hypolydian Mode.

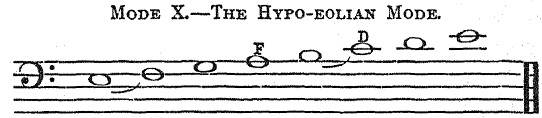


d r m f s l t d^1

Mode VIII.—The Hypomixolydian Mode.

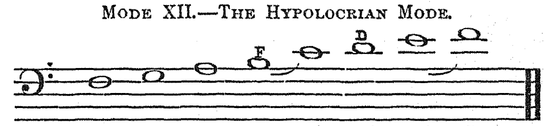
r m f s l t d^1 r^1

Mode X.—The Hypo-eolian Mode.



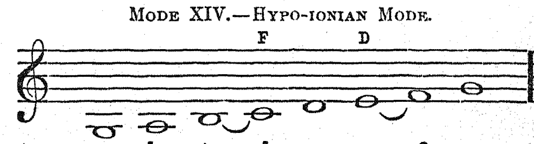
m f s l t d^1 r^1 m^1

Mode XII.—The Hypolocrian Mode.



f s l t d^1 r^1 m^1 f^1

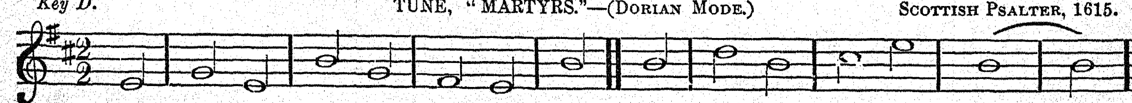
Mode XIV.—Hypo-ionian Mode.

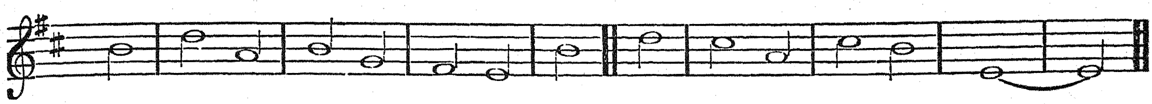


s_1 l_1 t_1 d r m f s

Note.—Because of the imperfect fifth from the final to the fifth above, the Locrian Mode, with its "hypo," was rejected.

The influence of Gregory on much of the music that has appeared since his time has been very great, and, in the church particularly, is still largely felt, many of what may be called the folk-songs of Scotland, Ireland, and Wales being examples of airs constructed on his principle. The familiar strains of "Scots wha hae" and "Waes me for Prince Charlie" are bright specimens of melodies founded on the Mixolydian mode; "John Anderson my jo," as it originally stood, illustrated the Eolian; and out of the many that claim our attention the following tune may serve to show how freely the Dorian, "ever a favourite and effective mode," was used by our forefathers:—

Key D. TUNE, "MARTYRS."—(Dorian Mode.) Scottish Psalter, 1615.

:r	f :r	l :f	m :r	l	l	d^1 :l	t :r^1	l :—	—
Their	blood a -	bout Jer -	u - sa -	lem	Like	wa - ter	they have	shed.	



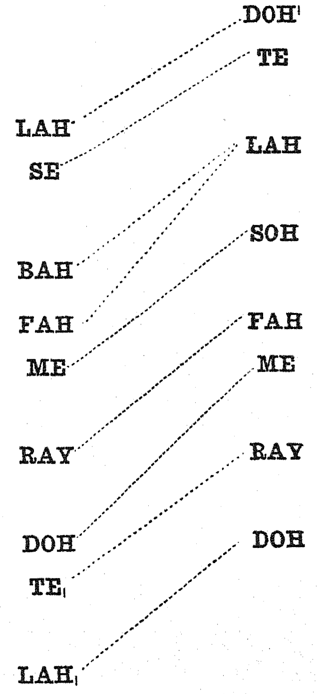
:l	d' :s	l :f	m :r	l	d'	t :s	t :l	r :—	—
And	there was	none to	bu - ry	them	When	they were	slain and	dead.	

Gradually, however, as time advanced and the knowledge of harmony increased, it was found that the ever-shifting position of the semitones—which the use of these modes involved—besides producing effects which must have been very unpleasant to the ear, almost precluded the possibility of reducing harmony to anything like a science. Musicians therefore, by gentle degrees, discarded all but two of these modes or ways of using the scale—viz. that which has already been under consideration, called the major key, in which Doh is the principal, and that which now demands our attention, which is or may be called

THE MODERN MINOR.

This is founded upon the Eolian or Lah mode of Gregory and his musical successors. In this mode or way of using the scale, Lah is considered the tonic or key-note; Me, the third from or above Doh, being fifth from Lah, is dominant; Ray is subdominant; Te is supertonic; Doh is now mediant, or third of the scale; Fah, formerly subdominant, is now submediant, or sixth; and Soh, unless it is altered or thrown out altogether, must occupy the place of leading note. It was perhaps on the note last named (Soh, seventh in the scale of Lah), that musicians first found that modern harmony and ancient tonality could not be brought to agree. One of the first principles of harmony is that the dominant of the key must bear a major chord, of which the chords of Doh, Soh, and Fah—already known to the student—may be taken as models. A little consideration will show that if Me is taken as the root, and Soh as the third of a chord, the imitation could not be the same as the models given, because Fah is distant half a tone from Me, and Soh a whole tone from Fah, thus giving only a tone and a half from the root to the third note above (called a minor third), instead of two full tones (a major third), as in the other chords named. So it came about that, for purposes of harmony, a new note was introduced. This note is half a tone higher than Soh, and becomes the leading note to Lah, thus assimilating the chord of Me to its models. This new tone is called Se. Both in melody and harmony the notes Lah, Se, Lah are to be considered as occupying the place of Doh, Te, Doh. The Lah-mode phrase is more mournful in effect, but is otherwise an exact imitation. This note Se, having been introduced for harmonic reasons, was found neither so desirable nor requisite in melody, more particularly in descending passages. Being the sharpened or raised seventh, it is often used in ascending the scale, while Soh, the unaltered note, is employed in coming down. Further, if the student will carefully examine the modulator here given he will find that when the sharpened seventh is employed a great gap (called an augmented second) occurs between Se and Fah, the note below it. The ear naturally objects to this gap, and to do away with it musicians were fain to introduce another note to take the place of Fah; in other words, when in melody the tone Se is to be employed the tone Fah is frequently raised or sharpened half a tone, the note thus introduced being called Bah. Thus for reasons connected with harmony the note Se was originated, the consequence being that melody demanded a second alteration. There are, then, four ways in which the minor scale may be and has been used by nearly every composer of any eminence—viz. First, the unaltered notes ascending and descending, which, as will be seen, is equivalent to the authentic Eolian mode of Gregory. Second, that in which the notes Bah and Se are used, called the arbitrary minor scale. In the Third, Bah and Se are used in going up, and are replaced by Soh and Fah in the descent. This may be considered partly arbitrary and partly natural. Fourth, that in which Se and Fah are employed. This is called the harmonic minor scale, because Fah and Se are the notes used in harmony. Let the student make careful study of these (given below), and endeavour if possible to hear them played or sung. The modulator exhibits the relation between the minor and the ordinary major scale.

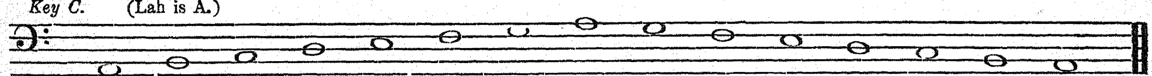
MINOR MODE MODULATOR.



DIFFERENT FORMS OF THE MINOR SCALE.

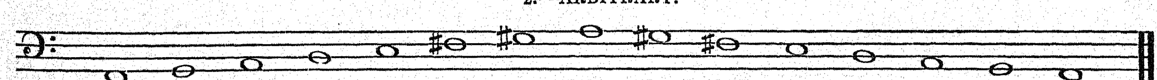
1.—ANCIENT.

Key C. (Lah is A.)



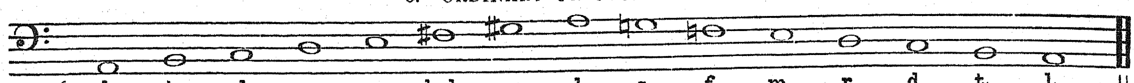
l, t, d r m f s l s f m r d t, l,

2.—ARBITRARY.



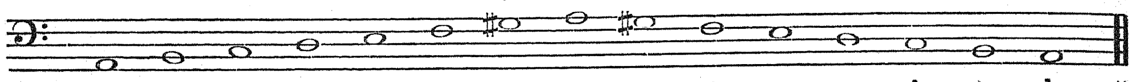
l, t, d r m bah se l se bah m r d t, l,

3.—ORDINARY OR USUAL FORM.



{ l, t, d r m bah se l s f m r d t, l, ||

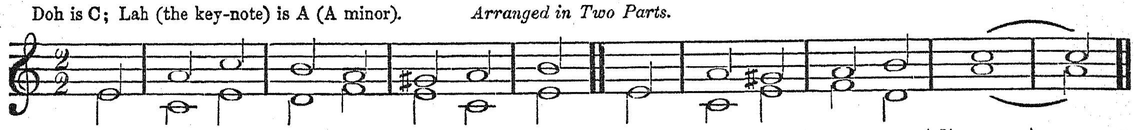
4.—HARMONIC.



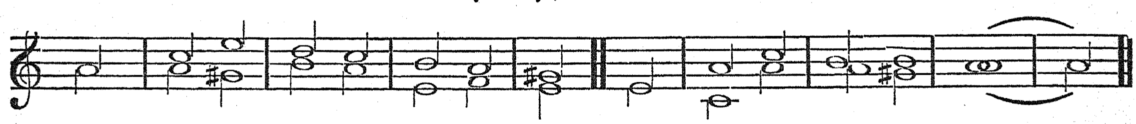
{ l, t, d r m f se l se f m r d t, l, ||

Exercise 98.—TUNE, "CULROSS." *From* SCOTTISH PSALTER, 1615.

Doh is C; Lah (the key-note) is A (A minor). *Arranged in Two Parts.*

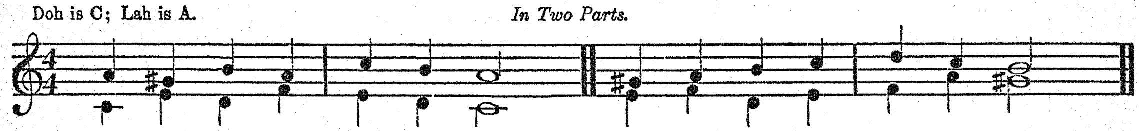


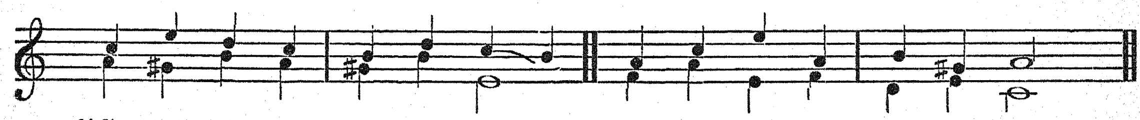
{:m |l :d' |t :l |se :l |t ||m |l :se |l :t |d' :— |— ||
{:m |d :m |r :f |m :d |m ||m |d :m |f :r |l :— |— ||
Mine end and meas - ure of my days, O Lord, un - to me show



{:l |d' :m' |r' :d' |t :l |se ||m |l :d' |t :t |l :— |— ||
{:l |l :se |t :l |m :f |m ||m |d :l |l :se |l :— |— ||
What is the same, that I there - by My frail - ty well may know.

Exercise 99.—TUNE, "MORNING." JAS. SNEDDON, Mus. Bac.

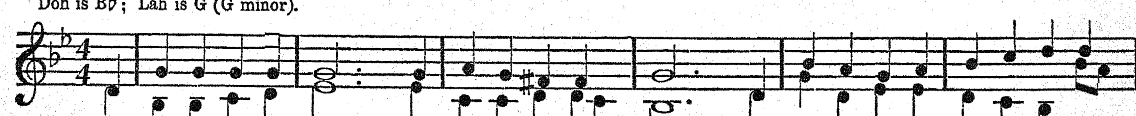
Doh is C; Lah is A. *In Two Parts.*

{|l :se |t :l |d' :t |l :— ||se :l |t :d' |r' :d' |t :— ||
{|d :m |r :f |m :r |d :— ||m :f |r :m |f :l |se :— ||
Come, my soul, thy suit pre - pare; Je - sus loves to an - swer pray'r.



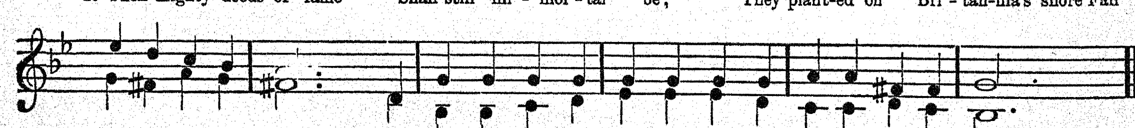
{|d' :m' |r' :d' |t :r' |d' :t ||l :d' |m' :l |t :se |l :— ||
{|l :se |t :l |se :t |m :— ||f :l |m :f |r :m |d :— ||
He him - self has bid thee pray, There - fore will not say thee nay.

Exercise 100.—OUR FATHERS, WHERE ARE THEY? ROOT.

Doh is B♭; Lah is G (G minor).



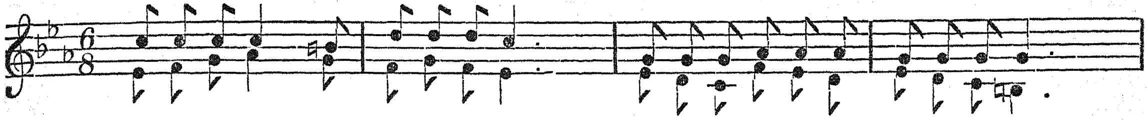
{:m, |l, :l, |l, :l, |l, :— |— :l, |t, :l, |se, :se, |l, :— |— :m, |d :t, |l, :t, |d :r |m :m }
{:m, |d, :d, |r, :m, |f, :— |— :f, |r, :r, |m, :m,.r, |d, :— |— :m, |l, :m, |f, :f, |m, :r, |d, :d.t, }
1. Our fa-thers, where are they? The no - ble, true, and brave; They sleep in peace, their la - bour o'er, With-
2. Their mighty deeds of fame Shall still im - mor - tal be; They plant-ed on Bri - tan-nia's shore Fair



{|f :m |r :d |t, :— |— :m, |l, :l, |l, :l, |l, :l, |l, :l, |t, :t, |se, :se, |l, :— |— ||
{|l, :se, |t, :l, |se, :— |— :m, |d, :d, |r, :m, |f, :f, |f, :m, |r, :r, |m, :r, |d, :— |— ||
in the si - lent grave. They sleep in peace, their la - bour o'er, With-in the si - lent grave.
free-dom's glo-rious tree. They planted on Bri - tan - nia's shore Fair free-dom's glo-rious tree.

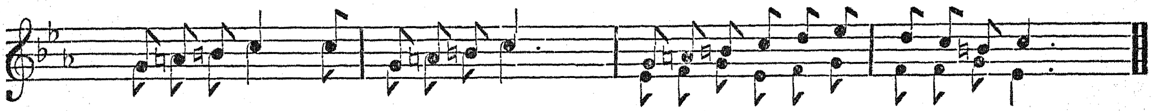
Exercise 101.—OVER THE MOUNTAIN.

Doh is E♭; Lah is C (C minor). *To illustrate the raised or sharpened Sixth* (Bah). *Arranged by* J. S.



|l :l :l |l :— :se |t :t :t |l :— :— |m :m :m |f :f :f |m :m :m |m :— :— |
|d :r :m |f :— :m |r :m :r |d :— :— |d :t_1 :l_1 |r :d :t_1 |d :t_1 :l_1 |se_1 :— :— |

1. O - ver the moun - tain, o - ver the plain, Would we re - turn to the old home a - gain;
2. Why should we lin - ger far, far a - way While in its shel - ter we soon should be gay?



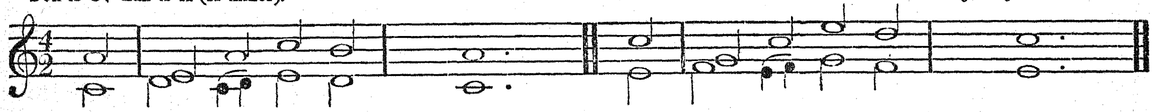
|m :bah: se |l :— :l |m :bah: se |l :— :— |m :bah: se |l :t :d' |t :l :se |l :— :— ||
|m :bah: se |l :— :l |m :bah: se |l :— :— |d :r :m |d :r :m |r :r :m |d :— :— ||

Far we have wan - der'd from the lov'd shore; But ah! no grief can the lost ones re - store.
What tho' the lov'd ones nev - er re - turn? Tears should be joy - ful we shed by their urn.

Comparatively few tunes or pieces begin, continue, and end in the minor key or mode. Nearly all "modulate" into the "relative major," *i.e.* Doh assumes for the time its usual importance. In the tune "St. Bride's," the second section repeats in the major or Doh mode what the first or opening section has given out in the minor. This tune also illustrates in its third section the use of the unaltered seventh (Soh) in the descending minor scale. The song that follows has a "modulation," *i.e.* a harmonic change of mode, at the end of the third line and the beginning of the fourth.

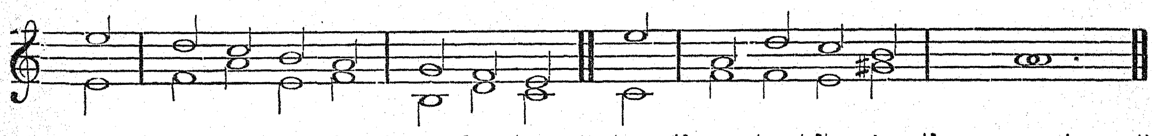
Exercise 102.—TUNE, "ST. BRIDE'S." SAMUEL HOWARD, Mus. Doc.
Arranged by J. S.

Doh is C; Lah is A (A minor).



:l |m :l |d' :t |l :— |— ||d' |s :d' |m' :r' |d' :— |— ||
:d |r :d.r |m :r |d :— |— ||m |f :m.f |s :f |m :— |— ||

Now for thine own name's sake, O Lord, I thee en - treat,



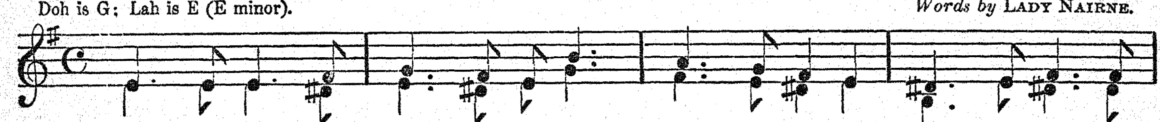
:m' |r' :d' |t :l |s :f |m ||m' |l :r' |d' :t |l :— |— ||
:m |f :l |m :f |t_1 :r |d ||d |f :f |m :se |l :— |— ||

To par - don mine in - i - qui - ty, For it is ve - ry great.

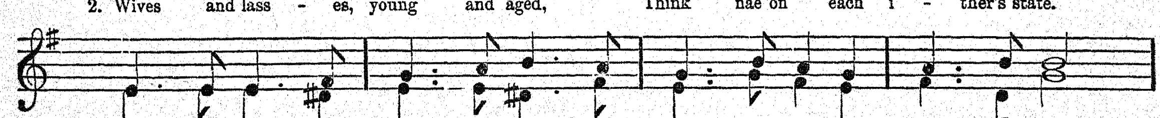
SAW YE NE'ER A LANELY LASSIE.

SOLO or DUET.

JAS. SNEDDON, Mus. Bac.
Words by LADY NAIRNE.

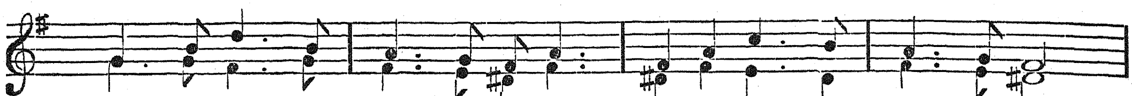
Doh is G; Lah is E (E minor).

|l_1 :-.l_1 |l_1 :-.t_1 |d :-.t_1 |l_1.m :— |r :-.d |t_1 :l_1 |se_1 :-.l_1 |t_1 :-.t_1 |
|l_1 :-.l_1 |l_1 :-.se_1 |l_1 :-.se_1 |l_1.d :— |t_1 :-.l_1 |se_1 :l_1 |m_1 :-.l_1 |se_1 :-.se_1 |

1. Saw ye ne'er a lane - ly lassie, Think - in' gin she were a wife, The
2. Wives and lass - es, young and aged, Think nae on each i - ther's state.

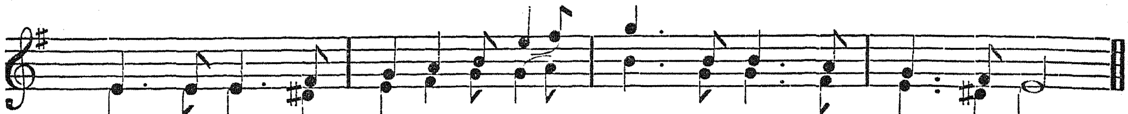


|l_1 :-.l_1 |l_1 :-.t_1 |d :-.r |m :-.r |d :-.m |r :d |r :-.m |m :— |
|l_1 :-.l_1 |l_1 :-.se_1 |l_1 :-.l_1 |se_1 :-.t_1 |l_1 :-.d |t_1 :l_1 |t_1 :-.s_1 |d :— |

sun o' joy wad ne'er gae down, But warm and cheer her a' her life.
Il - ka ane it has its cross - es; Mor - tal joy was ne'er complete.



| d :- .m | s :- .m | r :- .d | t$_1$ .r :— | t$_1$:r | f :- .m | r :- .d | t$_1$:— |
| d :- .d | t$_1$:- .d | t$_1$:- .l$_1$ | se$_1$. t$_1$:— | se$_1$:t$_1$ | l$_1$:- .se$_1$ | t$_1$:- .l$_1$ | se$_1$:— |

Saw ye ne'er a wear - ie wifie, Think-in' gin she were a lass,
Il - ka ane it has its blessings, Peev - ish din - na pass them by,

| l$_1$:- .l$_1$ | l$_1$:-.t$_1$ | d :r | m.l :- .t | d' :- .m | m :- .r | d :- .t$_1$ | l$_1$:— ||
| l$_1$:- .l$_1$ | l$_1$:-.se$_1$ | l$_1$:t$_1$ | d.d :- .r | m :- .d | d :- .t$_1$ | l$_1$:- .se$_1$ | l$_1$:— ||

She wad aye be blythe and cheer - ie, Light - ly as the day wad pass.
But like choic - est ber - ries seek them, Tho' a - mong the thorns they lie.

DRAWING.—CHAPTER VI.

LANDSCAPE. NO. II.

We shall now suppose that the student is able fairly well to sketch from nature in black and white a simple outdoor subject, consisting of one primary object and its surroundings. This may seem a small thing to be able to do, and it is truly a very elementary acquisition in landscape painting; but like most elementary work, it is necessary that it should be thoroughly done, and we therefore advise the student to repeat the whole of the exercise again and again, and if possible show these drawings to some artist or well qualified friend. The student need not be afraid to show his work to an accomplished artist if he has an opportunity; for no true artist will be likely to look carelessly or scornfully upon early earnest efforts. He will have far too keen and strong a recollection of his own struggles and failures. The student may feel assured of kindly criticism and even suggestive help, providing he is on the right tack, and is patiently striving to master the *elements* of his art. But if (as sometimes is the case) the tyro—with untrained mind and unschooled hand—brings his nerveless drawing or crude colour, and expects praise while pretending to seek advice, the artist must either repel the intruder unsatisfied or conceal his discomfort and annoyance while dismissing the applicant with polite but vague generalities.

These sketches, or rather drawings, of simple rigid objects—done with care and much detail—should be made at every opportunity, even when more advanced work has been reached. No ambitious student, however, will long be content with such things. He will feel impelled by a strong desire to group objects, and to represent them in conjunction with sky and water, and other attractive surroundings; to give human interest to the sketch by the addition of figures; and, above all, to simulate, or in some degree represent, the glorious *colour* which is one of the chief charms of nature's works.

Of these things we now desire to speak. The student who has carefully followed this course of lessons will know and feel, we are sure, that it is useless for him to attempt higher branches—the subtleties and mysteries of art—unless he has sedulously studied, if not thoroughly mastered, the more elementary subjects which have previously engaged his attention and efforts. Indeed, some good authorities consider that the higher branches of art ought never to be attempted by the amateur. Mr. Ruskin says that excellent drawings in light and shade may be made by those who can only devote themselves to art during the intervals of business, but that those alone should attempt to colour who can give their lives to the work. This seems a hard saying, for there is such a strong and universal love of colour among all classes that it seems ungracious indeed to deny to those who show by intense study of art that they have a heartfelt appreciation of the beautiful, the pleasure and delight of working in colour, and of endeavouring to depict, in some degree, the glorious hues and tints of the natural world. While therefore we strongly urge the student not to attempt to sketch in colour until he has achieved full skill in the elements of drawing and shading, we shall—notwithstanding the difficulties of the subject—endeavour to give some instructions and directions regarding the use of colour.

The chapter on "Light and Shade," p. 470, and especially that part referring to *tones* or *values*, should be carefully restudied before commencing colour, and all the exercises there recommended should be specially worked with the brush, using various single colours, as red, brown, or green. By this means some knowledge of the materials will be gained, as well as an increased knowledge of light and shade, and tone or strength of colour.

Fig. 1.

The Village of Brolle—Forest of Fontainebleau.

It would also be good practice to copy in *monochrome*, and on a large scale, some of the drawings given as illustrations of this chapter, putting a single wash of colour to imitate each tone used in the sketch (see fig. 1). The figures and all details may be omitted in these exercises.

When a fair amount of skill and confidence has been acquired in the use of the brush by monochrome practice, a few colours or pigments may be obtained and their properties carefully studied. High authorities on the selection of colours give advices so varied and so contradictory that inquirers are likely to be confused by counsellors. Only two courses seem left—either (1) to pin our faith to some one writer, or (2) to reject all advice and prove the value and permanence of our colours by the slow processes of our own experience.

As general readers may not have access to special books on colours, we shall give a list of those pigments which are suitable for landscape painting. The list will be a short one, as students most frequently err in having too many colours than too few. They are led into that error by the recommenda-

tion of well-meaning friends, and inclined to it by the natural desire of finding an easy way out of inevitable difficulties and disappointments by the purchase of yet another colour. That beautiful work can be done with very few colours has often been proved. Sir Joshua Reynolds and Etty, two of our greatest colourists, used very few pigments. Reynolds is said to have painted many of his pictures with five colours only, or seven including black and white. These colours were—Naples yellow, yellow ochre, lake, carmine, ultramarine. Among the great painters of our own time Sir Frederick Leighton uses only fourteen colours, and Alma Tadema thirteen; both these artists are specially noted for the beauty of their colouring, and yet they succeed with comparatively few colours.

In comparing the lists used by great artists we find that they are seldom alike, and often very unlike. When these artists speak or write about colours their opinions are as various as their palettes, and those who read these opinions are generally left in what Mr. Ruskin calls "the wholesome state of not knowing what to think." Sometimes, however, these lists are very similar, and when we find that two well-known and successful artists are in the habit of using almost the self-same colours, and yet producing with them wholly different results, we come pretty near a settlement of this difficult problem. We subjoin two such lists—and leave the student to choose either of them, or to make a fresh list of his own by combining the colours—used respectively by

Alma Tadema, R.A.		J. C. Hook, R.A.	
	White.		White.
Yellows,	Naples Yellow.	Yellows,	Naples Yellow.
	Yellow Ochre.		Yellow Ochre.
	Raw Sienna, or Brown Ochre.		Roman Ochre.
	Cadmium.		Deep Lemon Yellow.
Reds,	Orange Vermilion.	Reds.	Vermilion.
	Chinese Vermilion.		Indian Red.
	Light Red.		Purple Madder.
	Madder Lake.		
	Burnt Sienna.		
Blue,	Cobalt.	Blues,	French Ultramarine.
			Cobalt.
	Green Oxide of Chromium.		Vandyke Brown.
	Ivory Black.		Plumbago.

A careful comparison of these lists will show that they are singularly alike, especially when we consider that in some cases—namely, ivory black, plumbago, brown ochre, Roman ochre—the difference is chiefly in name. This similarity of materials is all the more wonderful when we consider the wide difference in the work done—the picture produced. In the one case we have classic figure subjects, brilliant, yet charmingly tender in colour, highly finished, and altogether lovely; while in the other case we have rugged coast scenery, broad breezy-looking pictures of the sea, weather-stained fishermen at their work, the dark angry storm cloud, or the gorgeous hues of the sunset-sky.

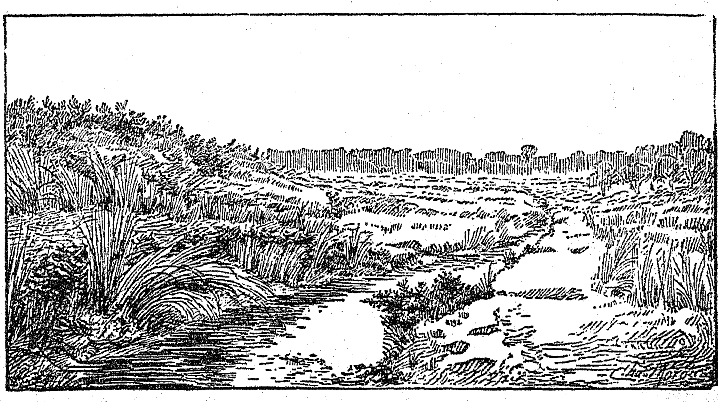
If all this work can be done with the small number of colours named in the above lists, these lists may safely be taken as guides, and we should be cautious how we depart from or add to them. A very good set of water colours might be made from Mr. Alma Tadema's list by the omission of Naples yellow, Chinese vermilion, and green oxide of chromium, and the substitution of lemon yellow, French blue, and sepia.

Having obtained such a set of colours as we have indicated, the next step is to learn their names, their properties, and their possible combinations. This will be all the more easily done if the colours be properly arranged in the water-colour box, or on the palette. We have, with this in view, made out the lists in the order in which they should be placed, commencing with white and ending with black. This order should be strictly adhered to, so that it may be known exactly where to find a colour when it is wanted without having to think about it, just as the musician knows where to find the note on the piano.

When rightly arranged the names of the colours are easily learned. The tint represented by the name should also be thoroughly known. This can soon be done by making a blot of each colour on a piece of paper, taking the colours in regular rotation, calling them by name or writing the name underneath each time. Many of these colours are familiar to all, so that half an hour's study should make the student sufficiently familiar with them. The possible combination of these colours is a greater and far more difficult study. They are simply infinite, and a knowledge of them is only gained by long experience. The beginner should at least know the following elementary facts concerning these combinations:—All colours are either red, blue, or yellow (see lists); these are the elemental or primary colours. By mixing any two of these we get a secondary colour, as red-blue = purple, or blue-yellow = green; by adding a small portion of the third primary we partially neutralize the green or the purple, and by mixing the three primaries in certain proportions we make a gray or neutral colour. Yellow ochre and madder lake mixed together make orange; a little cobalt added to this mixture makes a delicate gray suitable for the tender tints of skies. Simple as this principle is, it underlies almost all mixtures; and it would be found exceedingly useful to make sundry experiments in these directions, trying the mixture of any two colours in the above list, taking one from each bracketed division, and then watching the result of the addition of a small quantity of a third colour taken from the remaining divisions. Some practice of this sort is desirable before any attempt is made to use any of these possible combinations for the purpose of imitating the colours of natural objects.

The colours of a landscape are so varied and so constantly changing under the influence of the ever-changing sky that no rules can be given here for the imitation of them. The best advice that can be given is to practise first by copying the colours of simple objects indoors, until some knowledge of the combination of colours and some power of imitation of tint is acquired. A careful study of landscape tints and tones may be made while the student is still working in black and white. Suppose, for example, that fig. 2 is a pencil sketch representing a moorland brook and distant wood in late autumn, a careful (written) description might be made of the colour in the following manner:—Sky, warm yellow tint, with tender gray clouds; distant wood, dark neutral pur-

Fig. 2.



ple, with soft blue-gray mist at base; distant moorland, gray and misty, with indefinite lines of orange, purple, and green; shadows of near bank and reflection in brook, strong rich brown; flat banks of brook (left white in sketch), light pure green; gorse, rushes, &c., in foreground, chiefly strong orange and purple. Any such description would, of course, convey a very inadequate idea of the scene to another person, but it would help immensely to fix the impression in the mind of the observant writer; and some scores of such notes would lead to that careful observation of nature without which no good art-work can be done. The practice, so common in our

schools, of copying from landscapes is of little (if any) real use, especially if the landscapes copied are cheap lithographs of poor quality. They are more likely to vitiate than improve the taste. If a really good picture or drawing could be procured it would benefit the student at that stage in his studies when he has begun to know and to grapple with some of his difficulties, to make a careful copy of it.

When it is not possible to get permission to copy a good picture the utmost use must be made of the excellent examples in museums and exhibitions, which are now fortunately accessible to many, if not to all. In these exhibitions the student will naturally be attracted to those pictures which are similar to the work which he is himself trying to execute. Elaborate written notes of the colour, composition, and execution of such pictures should be made, and by such careful study the student will see how certain difficulties which he has already encountered have been overcome, or at least dealt with. To study in this way half-a-dozen pictures in a large collection will do infinitely more good than aimlessly sauntering round the room, looking at everything, and really seeing nothing to purpose.

We can give within our limited space but a few broad and brief instructions on *manipulation*, or the methods of using colour. The brush is a much more difficult instrument to handle than the pencil. It is only after much practice that it can be used with confidence. Trouble and disappointment may be, in some measure, avoided by choosing good brushes to begin with. The hog's-hair brushes for oil should be flat, thin, and springy, the edge being even and fine like that of a carpenter's chisel; the sable brushes, for oil and water colour, should be of the best quality. They are rather expensive, but with care they last for years.

No trust should be placed in mediums. The vendors of such things, knowing the weaknesses of human nature, advertise the wonderful powers and qualities of some new mixture, and the credulous amateur buys in the delusive hope that the use of this composition will give to his picture that tone and brilliancy which he feels it lacks. A story is told of a famous artist that, being pestered with the question, "What do you mix your colours with?" he answered brusquely, "With brains, sir, brains." This is really the only trustworthy recipe: constant study, thoughtfulness, and care; by these, and not by the use of "mediums," will a satisfactory result be obtained. Nor is there much to be done by the preparation of paper or of "grounds;" the paper and the canvas, as sold by the best makers, are ready to work upon.

The old-fashioned methods of "first painting," "second painting," &c., are not much taught or practised now. It is far better to try to get the result aimed at *at once, with one painting*. Most probably the result will not be satisfactory, and the work will have to be gone over again, but it will be done all the better for the bold effort to do it right offhand.

Gray effects—those in which the varieties of tone and colour can be obtained by the addition of very small atoms of pigment—are those with which it is best to begin. Brilliant colours are much more difficult to manage, and by using them the beginner is more likely to make his picture gaudy than beautiful. It is an evidence of want of real art-culture to see beauty only in strong contrasts and in bright colours.

The hog's-hair brushes used in oil painting should be held long, the colour put on thickly and moved cautiously, every touch being looked upon as final; in water-colour the brush should be used full, the colour flowing, all stippling, hatching, and retouching being as much as possible avoided. Touching up is inevitable, and much may be done by it, but the student should not expect too much, and deceive himself with the thought that "it will all come right in the glazing."

The introduction of figures is not always necessary to a landscape, but it is often desirable. To do this well, it is not only necessary to be able to draw the figure or figures, but also to have the power to place each in its proper position. The former power may be acquired by study, but the latter seems truly to be a gift—a gift, moreover, which some artists never acquire.

The safest way to put in a figure is to draw it from nature on the spot, at the same time as the landscape is drawn. This, of course, is not always possible—the figure may not be there, or may not be suitable. Yet to introduce it at home from photos or prints is far more hazardous than to take or use what is truly seen.

We ought first of all to consider very carefully whether a figure is really desirable. Figures are often introduced which injure rather than improve a picture. Figures are desirable when the surroundings imply or suggest them. For example,

Fig. 3.

the road (fig. 3) naturally leads one to anticipate that there should be figures on it. The whole picture would look blank without them, while the solitariness of the moor (fig. 2) is best suggested by the absence of animate objects. In this, as in most other matters worthy of study, the best course is neither short nor easy. Having decided on the introduction of a figure, its position and size should be determined; this can be fixed upon fairly well by sketching roughly the idea on a piece of glass and arranging it on the easel in front of the picture, so that its effect in various positions can be observed, criticised, and studied. Then various separate sketches or studies of suitable figures should be made. These should be done out of doors, of a large size. They need not for this purpose be highly finished, but their general form and the tone or value should be very carefully imitated. One of these studies—the most suitable, of course, to the nature and suggestions of the scene—should then be selected; and after the knowledge gained in the painting of it out of doors, it should be comparatively easy to introduce it appositely into the picture at home.

A strong inclination to elaborate these figures is often felt. This must, as a general rule, be stoutly resisted; for the figure, as an adjunct or accessory to the landscape, should not be more highly finished than the landscape itself. Studies of other objects, such as those shown in Plate VII., should also be made, and may also be introduced into the foregrounds of pictures. These studies can seldom be used for more than one landscape. In another scene and in other surroundings they would evidently be out of place and discordant, if they have been well and wisely chosen at first for the work on hand. This accounts for the fact that those very beautiful photographs of figures, animals, and other subjects, which are now so cheap and abundant, are really not very useful. Both artist and amateur are tempted to buy them—they are beautiful to look at—it is a pleasure to possess them; but the exactly suitable opportunity to use them never seems to arrive.

To make careful studies of the figure seems therefore to be the only proper course; and sometimes a study may be made so successfully as to suggest that a landscape be added to it by way of a background.

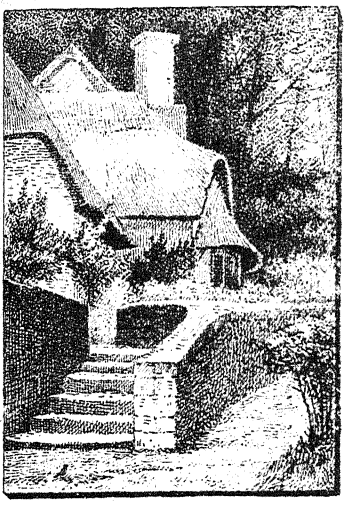
Many a beautiful picture which has won high admiration in our exhibitions has been produced in this effectively suggestive way. Thus, supposing that a study of a figure—such as that shown in fig. 4—has been successfully made. It may then, by a few slight touches admirably adapted to the sentiment of the figure, be happily transformed from a figure study into a landscape picture.

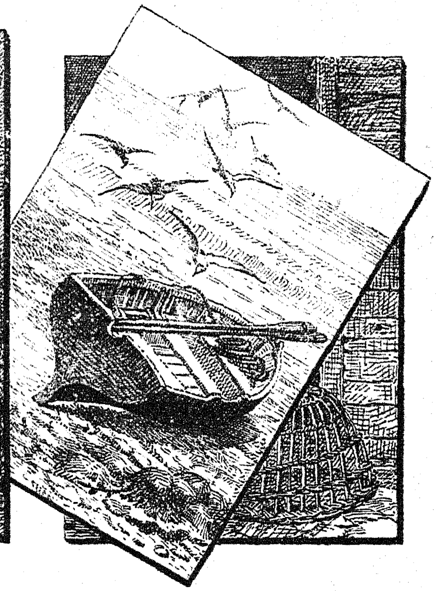
The old, strongly marked division between landscape and figure, as two distinct branches of art, is gradually growing

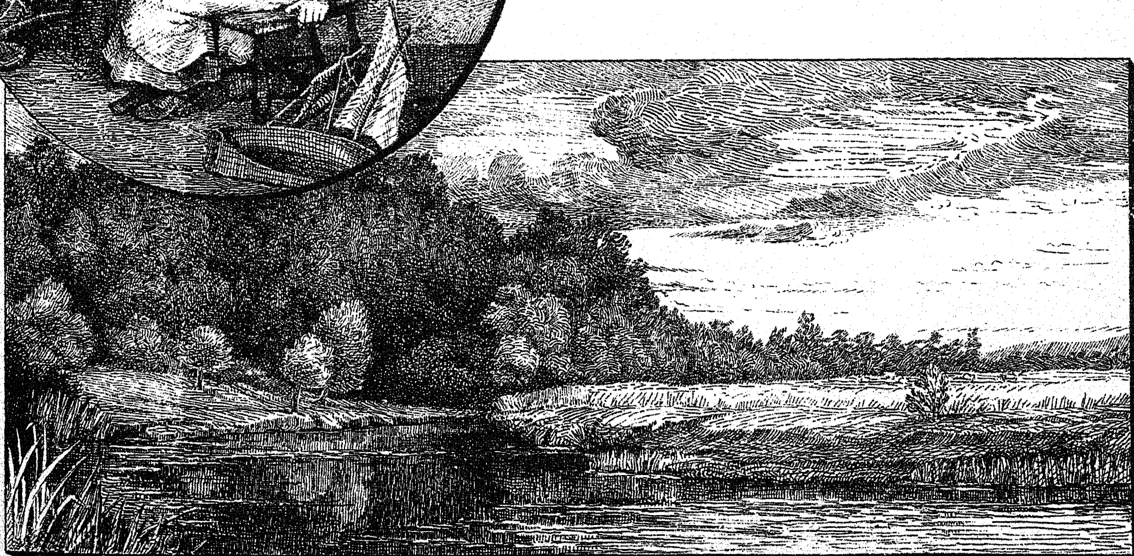
DRAWING.

LANDSCAPE.

PLATE VII







faint, and almost disappearing. Many of our best artists now paint both figure and landscape, and almost equally well. The same kind of preliminary study is needed for both; and if a very strong desire is felt to make figures a prominent part of a landscape or even to attempt a figure picture, the

Fig. 4.

diligent and successful cultivator of landscape art will find that the elementary study recommended in previous chapters will be exactly the kind of study most likely to fit him for the attainment of satisfactory success in his work.

TRIGONOMETRY.—CHAPTER VIII.

RESUMED CONSIDERATION OF OBLIQUE-ANGLED TRIANGLES—GEOMETRY OF THE FORMULÆ—EXERCISES.

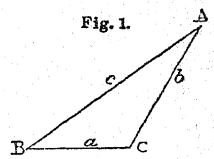
It is, admittedly, not strictly scientific to employ, as we have done, the logarithmic tables of sines, tangents, secants, &c., without having explained the nature and construction of these important and valuable aids in computation and mathematical investigations. It is not very easy, without wandering wide of one's marked courses, to treat, in the manner of a brief episode, of such an important matter as that invention which is due to the mathematical skill of Napier, and has been so extended in its usefulness by successive men of mark as to have become an indispensable assistant in scientific calculations. To give a definition of logarithms, to explain the theory on which they are based, to describe their uses, and to supply in such detail as would be of any advantage to a student, would really require a distinct treatise. In all derivative sciences, such as trigonometry is, something requires to be *assumed*, *i.e.* taken for granted. One cannot begin at the beginning with everything, and cannot run off into explanatory digressions, of any great length at least, if task, time, and space be all limited for him. Logarithmical tables have been constructed with such care and caution, and have been subjected to such test and trial in every kind of computation almost, that they can well be trusted, and almost any one who sees a logarithm quoted can by reference to almost any of the tables which are published in such numbers find whether it has been extracted exactly. This being the case, all the rest is easy. If a multiplication is to be effected, it is only necessary to extract from the tables the logarithms of the factors, and adding them together the answer supplies the logarithm of the product, and a fresh reference to the table supplies us at once with the number corresponding to this new logarithm, and that is the product. Similarly, in division it is only necessary to subtract the logarithm of the divisor from that of the dividend, and, by turning to the tables, find the number corresponding to this difference, and this is the quotient. Addition and subtraction thus perform for us the long and tedious processes of multiplication and division, and logarithms are found to be of invaluable service, especially in those operations where these are required to be done with great exactitude. What we have asked our students to do is to accept of the logarithms employed as genuine and accurate; all the processes of their manipulation have been, we hope, intelligibly explained—at least when examined carefully, after being accepted on authority, the student may readily test the operations before him, and certify himself of their exactness.

For instance, let us take this case:—A triangle is given of which the side A B is 532 yards, B C 358, and the angle C is 107° 40′, to find the remaining three parts; *i.e.* we are to find (1) the angle A, (2) the angle B, and (3) the side A C.

We know (p. 337, col. 2) that any two sides of a plane triangle are to one another as the sines of the angles opposite to them, *i.e.* that B C : C A :: sin A : sin B, or sin A : sin B :: C B : C A, or any equation of these proportionals. The ground of these formulæ may be found in Euclid VI. 16.

In this case we say A B : B C :: sin C : sin A. As C = 107° 40′ it is greater than 90°, and therefore—as has been explained (p. 473, col. 2)—we must take the sine of its supplement [*i.e.* 180° − 107° 40′ = 72° 20′], which is its trigonometrical equivalent. The logarithm of 72° 20′ is (as given in Elliot's Tables, which we use because at hand) 9·979019, the logarithm of 358 (the length of B C) is 2·553883, and the logarithm of 532 (the length of A B) is 2·725912. The two former require as proportionals to be multiplied together and divided by the latter. But, as we said before, multiplication is effected by the addition of logarithmic numbers, and division by the subtraction of them. The figures require to be arranged thus:—

Fig. 1.



Sin C [*i.e.* 180° − 107·40 = 72·20]	=	log 9·979019
+ B C, 358 yards	=	" 2·553883
		" 12·532902
− A B, 532 "	=	" 2·725912
Giving sin A = 39° 53 (or 140° 7′)	=	log 9·806990

We next proceed with the equation sin C : sin B :: A B : A C. Sin B is found thus:—B = 180° − (C + A), *i.e.* 107° 40′ + 39·53 = 147° 33′, and gives 32° 27′ as the equivalent of sin B, the logarithm of which is 9·729621. We know (or accept as true from the above-given figures) the logarithms of A B and sin C, and we arrange them thus:—

Sin B = 32° 27′ =	log 9·729621
+ A B, 532 yards = (as before)	" 2·725912
	" 12·455533
− sin C = 107° 40′ (or 72·20) =	" 9·979019
Giving for side A C 299·58, which is the equivalent of	log 2·476514

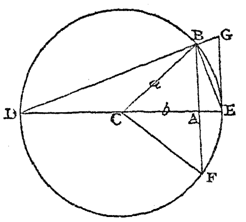
The angles are therefore A 39° 53′, B 32° 27′, and C 107·40 = 180°; and the side A C 299·58, or 300 nearly.

The geometrical proof of the accuracy of the method pursued in cases where two sides and a contained angle are given is of considerable interest, and may be made instructive if carefully followed and compared with the results embodied in the usual formulæ. It will be easily understood by referring to the annexed figure.

Let A B C be any plane triangle having the side B C [marked *a*] greater than C A [marked *b*], and from C as centre with C B [*a*] as radius describe a circle. Produce

A C to D and E, so as to form a diameter of the circle BDE. Produce B A so as to touch the circle in F and form a chord. Join DB, B E, and C F, and draw E G parallel to A B and meeting D B produced to G. Then because D C and C E

Fig. 2.



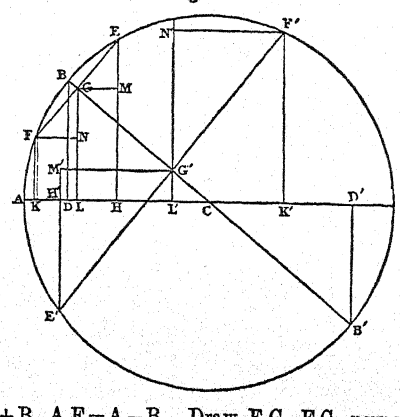
are each of them equal to C B [a], D A is equal to C B and C A [i.e. $a+b$], and A E to C B made less by C A, for equals taken from equals make their remainders equal. Again, by Euclid I. 32, the exterior angle D C B is equal to the two interior and opposite angles C A B and A B C [*i.e.* A+B], and by Euclid III. 20, the angle D E B at the circumference of the circle is equal to one-half of C A B plus A B C [*i.e.* $\frac{1}{2}$ (A+B)]. By Euclid I. 32, the exterior angle C A B is equal to the two interior and opposite angles A C F and A F C. A C F and A F C are (Euclid I. 5) equal to A C F and A B C, and therefore A C F equals C A B, made less by C B A [*i.e.* A C F = A − B]. Once more, by Euclid III. 20, F B E, or its equal B E G, is equal to A C F, or to one-half of C A B, made less by A B C [*i.e.* $\frac{1}{2}$ (A − B)]. If E B is now taken as unity, because, by Euclid III. 31, D B E, the angle in a semicircle, is a right angle, B D is the tangent of D E B [*i.e.* tan $\frac{1}{2}$ (A+B)], and B G is the tangent of B E G [*i.e.* tan $\frac{1}{2}$ (A − B)]. Then Euclid VI. 2 supplies us with the proportions D A : A E :: D B : B G [i.e. $a+b : a-b$ :: tan. $\frac{1}{2}$ (A+B) : tan. $\frac{1}{2}$ (A − B)]. This at once proves that the sides are proportional to the sines of the opposite angles, and interprets formula $a : b$ :: sin A : sin B, which we have been using, and which may be varied in several ways to suit computation; *e.g.*

$$\frac{a-b}{a+b}=\frac{\sin A-\sin B}{\sin A+\sin B}, \text{ or } \frac{a-b}{a+b}=\frac{\tan\frac{1}{2}(A-B)}{\tan\frac{1}{2}(A+B)},$$

or $a+b : a-b$ :: tan $\frac{1}{2}$ A + B : tan $\frac{1}{2}$ A − B. In these formulæ for the first and second terms the third will also be found given; for, by Euclid I. 32, A+B = 180 − C. In this way, too, when half the sum and half the difference of A and B are known, their angles become known, as has been beautifully shown in the following proposition by G. B. Airy.

To find the sine and cosine of the sum and difference of two arcs in terms of the sine and cosine of the simple arcs. Let A B (fig. 3), be the longer arc = A; B E = B F = B; then

Fig. 3.



A E = A+B, A F = A − B. Draw E G, F G, perpendicular to C B, which will meet at G and be in the same straight line, and will be equal; also draw B D, E H, F K, G L, perpendicular to A C, and G M, F N, perpendicular to E H, G L. Then E H or G L+E M = sin $\overline{A+B}$; F K or G L − G N = sin $\overline{A-B}$; C H or C L − G M = cos $\overline{A+B}$; C K or C L+F N = cos $\overline{A-B}$.

Now the angle E G M = 90° − M G C = C G L = C B D; also E M G and C D B are right angles, therefore the triangles E G M, B C D, are similar, and C B : C D :: E G : E M, or radius : cos A :: sin B : E M $=\frac{\cos A.\sin B}{r}$ = G N. And C B : B D :: E G : G M, or radius : sin A :: sin B : G M $=\frac{\sin A.\sin B}{r}$ = F N. Also C B : B D :: C G : G L $=\frac{BD.CG}{CB}$ $=\frac{\sin A.\cos B}{r}$; and C B : C D :: C G : C L $=\frac{CD.CG}{CB}$ $=\frac{\cos A.\cos B}{r}$. Substituting these values

$$\sin\overline{A+B}=\frac{\sin A.\cos B+\cos A.\sin B}{r};$$

$$\sin\overline{A-B}=\frac{\sin A.\cos B-\cos A.\sin B}{r};$$

$$\cos\overline{A+B}=\frac{\cos A.\cos B-\sin A.\sin B}{r},$$

$$\cos\overline{A-B}=\frac{\cos A.\cos B+\sin A.\sin B}{r}.$$

Or, if the radius be taken as the unit of measure,

$$\sin\overline{A+B}=\sin A.\cos B+\cos A.\sin B;$$

$$\sin\overline{A-B}=\sin A.\cos B-\cos A.\sin B;$$

$$\cos\overline{A+B}=\cos A.\cos B-\sin A.\sin B;$$

$$\cos\overline{A-B}=\cos A.\cos B+\sin A.\sin B.$$

We revert now to what we have previously said, with the intention of showing how interestingly trigonometry as a derivative science applies and supplies in its formulæ the highest results of the old geometrical methods, and reduces to shorthand, as it were, the cumbrous and intricate forms of reasoning they employed. We proceed to show, from the same figure, the geometric certainty of some other formulæ, which may be usefully adopted in the resolution of the cases of plane triangles.

Accepting as proved what we have already inferred from the relations exhibited in fig. 2, we note now that D B A is the complement of of A B E [*i.e.* $\frac{1}{2}$ (A − B)] and A D B is the complement of B E D [*i.e.* $\frac{1}{2}$ (A+B)]. Now, in the triangles A B D and A B E we have, by the law of the proportionality of sides, deduced from Euclid VI. 2 and 16, sin D B A : sin D :: D A : A B, and sin A B E : sin A E B :: A E : A B; formulæ which are capable of transformation into cos $\frac{1}{2}$ (A − B) : cos $\frac{1}{2}$ (A + B) :: $a+b$. c, and sin $\frac{1}{2}$ (A − B) : sin $\frac{1}{2}$ (A+B) :: $a-b$: c. These formulæ are readily proved otherwise. From Euclid VI. 16, we derive the proportions A C : B C :: sin B : sin A; hence we get

$$\frac{AC}{BC}=\frac{\sin B}{\sin A};\ \frac{\sin A}{\sin C}=\frac{a}{c};\ \text{and}\ \frac{\sin B}{\sin C}=\frac{b}{c}.$$

From these again, by addition and subtraction, and—because the sine of one angle of a triangle is equal to the sine of the sum of the other two angles—by the substitution for sin C, of its equivalent sin A+B, we have the formulæ

$$\frac{\sin A+\sin B}{\sin(A+B)}=\frac{a+b}{c}\ \text{and}\ \frac{\sin A-\sin B}{\sin(A+B)}=\frac{a-b}{c};$$

which are again transformable into

$$\frac{\cos\frac{1}{2}(A-B)}{\cos\frac{1}{2}(A+B)}=\frac{a+b}{c}\ \text{and}\ \frac{\sin\frac{1}{2}(A-B)}{\sin\frac{1}{2}(A+B)}=\frac{a-b}{c}.$$

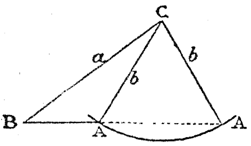
If the latter of the two formulæ is divided by the former the quotient will exactly tally with that which resulted from our geometrical deduction given above. It will be seen at once that $a+b : a-b$ :: sin A+sin B : sin A − sin B, thus

$$\frac{a-b}{a+b}=\frac{\sin A-\sin B}{\sin A+\sin B}.$$

In the case of two unequal sides being given, and the angle opposite to the less being that defined, the angle

opposite to the greater may be either (1) that found in the table of sines or (2) its supplement—unless, by the nature or the statement of the problem, we know, or may make out, whether that angle is acute or obtuse. In such a case as that mentioned there are two different triangles which may have the same *data*, and consequently for it the *data* are not sufficient to determine the triangle; *e.g.* from $\sin A = \frac{a}{b} \sin B$ or C A : C B : : sin B : sin A. In fig. 4 it is ambiguous, *i.e.* doubtful or rather indeterminate, whether we should make A less or greater than 90°—the two values being necessarily supplementary to each other, because they have the same sine and are in value less than 180°. Let A C (which is possibly also C A′) = 232, B C = 345, and the angle B = 37·20°. Of this the logarithmic sine is 9·782796; the logarithm of B C is 2·537819, and of A C 2·365488.

Fig. 4.



1. To find the angle A we say:—

Log sin B (37° 20′)	=	9·782796
+ log 345 B C	=	2·537819
		12·320615
− log 232 C A	=	2·365488
log sin A		9·955127

Therefore the angle B A C = log sin	115° 36′	or 64° 24′
To each add	37° 20′	37° 20′
	152° 56′	101° 44′
Take each from	180°	180°
Angle B C A =	27° 4′	or 78° 16′

2. To find A B we say:—

Log sin C = 78″ 16′	=	9·990829
+ log A C	=	2·365488
		12·356317
− log sin B		9·782796
		2·573521
= log		374·56

[*i.e.* A B = 374·56]

Or, in the second form,

Log sin C = 27° 4″	9·658037
+ log A C	2·365488
	12·023525
− log sin B	9·782796
	2·240729
or log	174·07

[*i.e.* AB = 174·07]

Which completes the solution of the triangle, but gives for A B two answers, because there are, as we have seen, two (possible) lengths which it may have.

HISTORY OF GREAT BRITAIN AND IRELAND.

CHAPTER VII.

HENRY III.—EDWARD I.—THE RELATIONS OF ENGLAND AND SCOTLAND.

JOHN's eldest son, a child of nine years old, was crowned in the King's Hall, Gloucester, on 28th October, 1216, as Henry III. William, earl of Pembroke, was made guardian of the king and warden of the kingdom. In the king's behalf Pembroke and Gualo, the Pope's legate, in a council held at Bristol, confirmed *Magna Carta*, excepting that clause which declared that the king should not tax those who held lands under him without their consent. Prince Louis having gone to France for fresh troops, many of the great earls in his absence did homage to Henry, and when the prince returned to besiege Dover he found affairs considerably changed. Lincoln Castle, under Nichola de Camville, widow of the governor, held out for Henry. The Earl of Perche and other nobles, 500 knights, and 20,000 soldiers beset it, occupying the town. The warden led an army to the rescue, and Gualo laid the papal ban on the prince and his followers. Perche fought desperately till he was slain by Pembroke. The English barons gave up their swords to the warden, the French fled, and by permission of their leaders the soldiery sacked the cathedral, castle, and town, and called the battle jestingly the Fair of Lincoln, 20th May, 1217. Louis fell back from Dover, the King of England to London, and awaited reinforcements to be brought by Blanche of Castile. Hubert de Burgh set out from Dover on 24th August against these, with forty ships, boarded them though they doubled his fleet, and towed them into Dover harbour, having given them all quarter except their commander, the monk Eustace. Louis, blockaded in London, agreed at Lambeth, 11th September, to evacuate the kingdom. *Magna Carta* was again confirmed and the Charter of Forests granted. Many of the barons went off to the Crusades, and Earl Pembroke died 1219.

Bishop Peter de Roche was then made guardian of the king, and Hubert, aided by Pandulph, the Pope's legate, ruled the land. Many intrigues of ecclesiastics against civilians caused trouble. Hubert was abandoned by the king, and De Roche gained the leading power. Henry gave freely to the Poitevins, and thus made foes. Then Stephen Segraves brought a papal rescript declaring the king of age, and new embroilments arose from Henry's jealous and wavering ways. The English grumbled at all good things going to foreigners, and compelled the king to dismiss them from his favour. The king's sister Joan had been taken to wife by Alexander II. of Scotland on the 25th June, 1221. Isabel was chosen by the Emperor Frederick, and in 1236 Henry married Eleanor of Provence, while, advised by Hubert, he gave the hand of his sister Eleanor to Simon de Montfort. Next year the king quarrelled with Simon, and accused Hubert of treachery. Hubert replied, "I was never traitor to you or yours, or you would not be king to-day." Simon, along with Richard, earl of Cornwall, the king's brother, went to the Crusades, in which, till 1242, they performed feats of valour and won high favour.

In the meanwhile Henry, disregarding the Great Charter, encroaching on the privileges of the barons, limiting the rights of burgesses by arbitrary exactions and oppressive measures, roused discontent among his subjects. On Philip's death, 14th July, 1223, Louis refused to restore the English provinces. Henry at a council demanded a subsidy of one-fifteenth of all movables to enable him to recover possession, but no successes were attained, only a few Gascon nobles being reduced. After concluding a disgraceful peace with Llewellyn of Wales, Henry gathered an army at Portsmouth for the invasion of France, peevishly allowed it to disperse, and then next year had a conflict with Louis, which ended in a five years' truce. Henry, urged by his mother, proposed to renew the war. The nobles refused to aid him. He headstrongly invaded France, was defeated, and a new truce was arranged. At last it was agreed that the great barons should make choice whom they would serve, and adhere solely to England or to France. Then patriotism inspired England.

On Henry's return he reigned not like a king but like a tyrant, claimed large gifts and made cruel exactions, the royal tax-gatherer himself receiving from the Jews with his own hand the benevolences he enforced. Innocent IV., too, became a rival gift-seeker. Against this, king and Parliament remonstrated, the Pope threatened and interdicted, and for a time both of them had their way. Indignant at the misgovernment from which they suffered, the people demanded that the powers of government should be invested in a commission of twenty-four bishops and barons.

This body met at Oxford, 11th June, 1257, and passed the "Provisions of Oxford," which Henry swore to implement. But finding that under De Montfort, earl of Leicester, and Richard de Clare, earl of Gloucester, the nation soon divided into two factions, Henry—having got a dispensation from the Pope—set at naught his pledges. A short civil war, in which the king used foreign mercenaries, ensued, but in 1262 he undertook to observe his oath. Dissatisfaction continued. Gloucester died 18th June, 1262, and in 1263 Leicester returned. He, in union with the son of Gloucester, attacked the king's favourites, captured many places held by the mercenaries, and compelled Prince Edward to surrender Windsor. King and barons referred their differences to the arbitration of Louis, and at a council at Amiens he annulled the "provisions" and reaffirmed the Great Charter. This reasonable award was disrelished by each party, and civil war was renewed. The fierce arbitrament of fight was resolved on. After various minor engagements, the armies of the king and the barons met on 13th May, 1264, at Lewes, in Sussex. The royal troops, despite the skill and daring of Prince Edward, were completely defeated; the king and his brother, Earl Richard, were made prisoners. Next day a truce, "the *mise* of Lewes," was agreed to. The king, nominally set at liberty, was retained in the camp, Earl Richard was committed to the Tower, and Dover was assigned as the prison of Edward and Henry, king of the Romans. "In all but name a king," Simon de Montfort ruled England. Queen Eleanor, who was exceedingly enraged at the burgesses of London for their objection to the luxurious living and profligate expenditure of the royal household, left England before the battle of Lewes to collect foreign troops. "Sir Simon the righteous" (as De Montfort was called in popular song, notwithstanding his being excommunicated by the Pope) called out the militia and massed them on Barham Downs, summoned the mariners of the Cinque Ports to proceed with him to sea, that they might meet the queen's fleet bringing over the forces she had collected at Damme. They never ventured to meet De Montfort's mariners. While keeping Christmas in high state at Kenilworth, Leicester issued writs in the king's name, summoning a Parliament. Eleven prelates, twenty-three peers, a hundred clergy of lower dignity, two knights from each shire, city, borough, and Cinque Port were called. They assembled 28th January, 1265. Prince Edward was allowed to go into "free custody" at Hereford, from which, however, he escaped in May. Strong securities were taken for Henry's

Hereford.

observance of charters and ordinances. But scarcely was the Parliament dissolved before a royalist rising took place under Gloucester, of which Edward, using the royal banner, took command. De Montfort, having the king in keeping, marched against them, and took up a position at Evesham, a town almost encircled by the Avon. While De Montfort was river-locked in this peninsular field, on 4th August, Edward, Gloucester, and Mortimer were seen advancing. He sallied out against them—having cried, "God have mercy on our souls, our bodies are theirs." They met at two in the afternoon. The king escaped. The earl, who fought like an enraged lion, was overpowered and shamefully mutilated, his son was slain, and a stormy nightfall darkened down on heaps of slain. The king's authority was, under safe limitations, restored in a Parliament held at Kenilworth, 1266. Those who had opposed him during the troubles were pardoned and offered peace; but from benefit of "the award of Kenilworth" all the De Montforts were excepted. Many of Simon's adherents refused submission, and betook themselves to the Island of Ely. Thither the royalists marched against them, and they were reduced 25th July, 1267. Meanwhile the Londoners besieged the papal legate in the Tower and plundered the palace of Westminster. The legate held a council in London, and another in Northampton, in which he aimed at settling the evils of the civil war. At the latter, the victor of Evesham and many of the barons took the cross, 1268, and went to the Holy Land, 1269. Llewellyn was received into amity. Henry restored its charters to London, 1270. In the Parliament of Marlborough, the "Provisions of Westminster," remedying the thirty grievances, were reissued. The rest of this reign, which owes little of its interest to the monarch from whose occupancy of the throne it derives its name, was quiet, and the last years of the feeble and fickle, wasteful and warm-tempered, superstitious and suspicious sovereign, were spent in peace. He had sunk into a distemper, which seemed unattended with

danger, but having gone to Norwich to quell a threatening sedition, in which he succeeded, he was, on his return, seized at Bury St. Edmunds with an access of his complaint, and died 16th November, 1272. He was buried in Westminster Abbey, which he had himself built on a sumptuous scale, where a tomb with his statue in brass was placed over him. He was in person middle-sized, strong, and compact, pleasant featured (though one of his eyelids drooped over the eyeball); in manners courteous and graceful, fond of poetry, art, and learning; a kind father and a good husband; greedy, yet fond of giving; easily influenced, not only by friends, but flatterers. Had he not possessed good qualities he could never have worn his crown so long even though so uneasily.

During this reign, besides "the English Ennius" (Robert of Gloucester) and the historian-chronicler Matthew of Paris, there flourished two other men of high note:—Robert Grosseteste—born at Stradbrook, in Suffolk, and first lecturer in the Franciscan School at Oxford — was bishop of Lincoln. He was learned above most of his contemporaries in Latin, Greek, Hebrew, French, mathematics, medicine, and music, and a most voluminous author. Roger Bacon—born at Ilchester, 1214—who preferred the study of nature to scholastic subtleties, and whose researches in mathematics, mechanics, astronomy, and optics—studied not only in Greek, Hebrew, and Arabian books, but by experiments on, and observation of nature—though pursued boldly, brought him persecution rather than renown.

Edward I., the greatest of all the Plantagenets, succeeded his father, Henry III. He was born on 18th June, 1239, in the palace of Westminster, and named after Edward the Confessor. Henry caused the great prelates, the chief nobility, and the leading citizens of London to take an oath of fealty to his young heir. Edward of the Flaxen Locks was carefully educated, and while he was yet a youth the prince was appointed governor of Guienne. The Gascons gladly accepted the new ruler, though Simon de Montfort resisted dispossession. As Alphonso of Castile had some political claim on Gascony, Henry proposed that a matrimonial alliance should be entered into between Edward and Eleanor, King Alphonso's sister, and that thereon Castile might transfer its rights to England. This was agreed to, and in 1254 the marriage took place, and the prince entered on public life as governor of Gascony, overlord of Ireland, chief of Wales, and Earl of Chester. His abundant labours and fightings during his father's reign have been already noticed. As a princely crusader his advent in Acre saved its garrison. His successes against the Saracens almost rivalled those of Cœur-de-Lion. He was wounded by an assassin, and a pleasing romantic tradition, perhaps fiction, relates how his well-beloved Eleanor sucked the poison from his pierced side. Edward left Palestine July, 1272. Tidings reached him, in Sicily, of his father's death, and that on Henry's funeral day, before the grave was closed, the great men of the realm had taken oath before the high altar of Westminster to be faithful to him as King of England.

Three guardians—Edmund, earl of Cornwall, Walter, archbishop of York, and Gilbert, earl of Gloucester—acted as regents in his absence. Edward, while passing through France, did homage to Louis for his French territories. He reached Dover on 2nd August, 1274. The ceremony of his coronation took place at Westminster on 19th August, Robert Kilwardby, archbishop of Canterbury, placing the crown on the brows of Edward and Eleanor. Alexander II. of Scotland and John of Bretagne, with their consorts, the king's sisters, assisted. The whole nation resounded with rejoicing.

Edward's first parliament was held in February, 1275. It was really a legislative assembly in which the members were employed in assisting to make the laws to which the nation was to be held bound, and the decisions of this council are entered on the statute-book of the realm as "the Acts of King Edward made at Westminster, at the first parliament general after his coronation, by his council and with the assent of the archbishops, bishops, earls, barons, and all the commonalty of the realm thither summoned." During the first eighteen years of his reign he asked and got four subsidies. Edward did not use his parliaments merely as a means for gaining money, but as agencies for the framing and establishment of good and salutary laws. Coke calls him "the English Justinian," and Sir Matthew Hale regards his reign as the "epocha of the true starting of the law of England."

Edward's reign was untroubled, while Eleanor lived, by any serious war except that with Wales, which arose in this way:—Llewellyn, as Prince of Wales, had been summoned to Edward's coronation, there to do that homage which was Edward's due. He subsequently was seven times called, and on 12th November, 1276, was, by the parliament, declared contumacious, and sentence was passed that he should be reduced to submission, "as and when the king thought fit."

The Welsh princes of North Wales, Brecon, and South Wales had chosen Alfred the Great as their "father and lord." This relationship had subsisted between the kinglets of Wales and the monarchs of England down to this time. Edward—who had meantime become possessed of Llewellyn's betrothed, Eleanor, daughter of Simon de Montfort, and had given shelter to David and Roderick, Llewellyn's brothers, and Griffith, prince of Powys, whom Llewellyn had deforced from his principality—insisted on homage being done, and in 1277 marched into North Wales. Llewellyn was reduced to submission, received his brothers into friendship, undertook to pay a large fine to Edward, and promised to do homage annually to him. Edward, on his part, acknowledged him as Prince of Wales for life, and not only gave him Eleanor, but provided a sumptuous wedding feast in Worcester, attended the marriage, invited the bridegroom and bride to be his guests at Westminster, remitted the fine, created Prince David an English earl, married him to an earl's daughter, and bestowed on him lands worth a thousand a year. After four years' tranquillity, David quarrelled with his English neighbours, and incited Llewellyn to rebellion. David, on Palm Sunday, 1282, seized Roger Clifford, chief justice of Wales, in Hawarden Castle, and slew many of his unarmed retainers. Then a raid was made on the English castles on the border-marches, Llewellyn's standard being carried by the assailants. After endeavours to secure peace through the intervention of John of Peckham, archbishop of Canterbury, had failed, Edward resolved on war. Llewellyn and David were excommunicated. A host of Gascon men-at-arms, Bearnese foot-soldiers, Irish kernes, Scottish horsemen, English nobles, and yeomen assembled under Edward's banner, and invaded Wales in menacing force. The Welsh were fiercely defiant. "We dare not," said they, "submit to Edward, nor will we suffer our prince to do so, nor do homage to strangers—whose tongue, ways, and laws we know nought of; we have only raised war in defence of our lands, laws, and rights." Edward proclaimed, "We now purpose, by the grace of God, to bring to an end the task of putting down the evil craft of the Welsh, which we have lately undertaken, by the advice of the peers and the great men of our realm and the whole commonalty thereof, for the lasting peace and quiet of ourselves and our whole realm." Anglesea was reduced. Llewellyn, dreading to be shut up in the mountain fastnesses of Snowdon, passed into Radnor. On 10th December, 1282, he crossed the Ivron. A party, under Edward Mortimer and John Gifford, sent in pursuit of Llewellyn by Edward, surprised the Welsh, and in an irregular skirmish Sir Adam Frankton, without knowing whom he had encountered, slew Llewellyn. His head was cut off and set up over the gate of the Tower of London. David assumed the title of prince, but the Welsh were entirely discouraged, and he was soon a wandering outlaw in the woodlands. After some months he was betrayed (June, 1283) by two of his own followers, and was tried by the Baronage of England on 30th September, at Shrewsbury, and sentenced to be hanged, drawn, disembowelled, and quartered. Edward held a Parliament at Rhuddlan, where, in the Statutes of Wales, he introduced, on the report of a commission, as many of the English laws and customs as were thought desirable, yet reserving to the Welsh, so far as possible, "all the rights, freedom, and estates they had enjoyed under the rule of their former princes." He provided for the children of Llewellyn and David, and in 1285 made a triumphal entry into London, carrying in his hand the Cross of St. Neot, a famous Welsh relic, which he deposited on the high altar of Westminster.

Meanwhile Edward began to build Carnarvon Castle. A

portion of it was speedily made ready as a royal residence. Early in 1284 Eleanor removed from Rhuddlan to this new abode, and there in a chamber in the eagle tower, on 25th April, a son (Edward) was born. He was presented to the Welsh as "their prince, and one, too, who could not speak a word of English." In 1301, at Chester, Edward received the homage of the Welsh freeholders as their accepted prince.

More than one trouble had yet to be borne from Wales. Rhys, the son of Meredith of South Wales, claimed in 1287 his father's principality, and, being refused it, rebelled. He was driven out of the country, raised an army in Ireland, invaded Wales in 1290, fought a pitched battle with the chief-justiciar Tiptoft, was defeated, taken prisoner, tried at York, condemned, and hanged. Four years afterwards a more resolute effort was made. Llewellyn's son Madoc caught and hanged the chief-justice, drove Edmund of Gloucester out of Wales, and defeated the Earl of Lincoln. He even besieged Edward himself in Conway Castle, and defeated two English armies. But the king's energy soon brought Madoc into such difficulties at Mynydd Digoll, that he was fain, in 1295, to throw himself on Edward's mercy. He was confined in the Tower, where he died.

On the last day of April, 1290, the Princess Joanna, born at Acre, was married to Gilbert de Clare, earl of Gloucester; on 9th July Margaret was taken to wife, in Westminster Abbey, by John, duke of Brabant. Mary had taken the veil in the convent of Amesbury, whither her grandmother Eleanor of Provence had retired. In this same year Queen Eleanor was seized with a slow fever. While a parliament was being held at Clipstow Palace, in Sherwood Forest, she was cared for in the Manor of Hardby, near Lincoln. Edward was by her sick-bed for eight days before her death, which took place 28th November, 1290. "Her funeral procession was one of the most striking spectacles England had ever witnessed," and wherever the queen's body rested—Lincoln, Grantham, Stamford, Geddington, Northampton, Stony Stratford, Woburn, Dunstable, St. Alban's, Waltham, Westcheap, and Charing—richly sculptured crosses were erected to her memory. Her body was laid in Westminster, where a recumbent effigy of the queen, in metal, was placed on a richly ornamented tomb. Edward was then fifty-two. His married life had lasted thirty-five years.

The remainder of the interest of Edward's reign eddies round and concentres in Scotland. The Anglo-Scottish monarchs descended from Malcolm Canmore and Saint Margaret, sister of Edgar Atheling, found Scotland a country drifting to desolation. During their dynasty they had raised it into greatness, freedom, and culture, with a powerful church and a thriving people. Under David an endeavour had been made to model the monarchical system of Scotland on that of England. Henry II., whom David had knighted at Carlisle, had promised never to disturb the slowly consolidating kingdom of the north, yet, under Malcolm the Maiden, succeeded in getting the four northern counties of England from Scotland, in exchange for the English earldom of Huntingdon. William the Lion, who had reclaimed against Henry's possession of these ceded territories, was, at Falaise, compelled to take the oath of fealty to the English king. An absolute renunciation of this obligation had been bought from Richard I. in 1189. Many other attempts to regulate the relations between England and Scotland had been made. Urged by Henry III. Alexander consented to do homage to him, and peace was consolidated between the crowns by the marriage of Alexander with Joanna, the English king's sister. A commission was then appointed to map out the boundaries between the two countries, but the commission was ineffective. On Alexander's second marriage to Mary, daughter of Ingelram de Couci, the friendship of the kings cooled. Henry demanded homage, and Alexander defiantly refused. The whole nobility of England were called out to enforce Scotland's submission. Alexander immediately surrounded himself with his best troops. A bloodless settlement was arranged at Newcastle. Henry waved his demand in regard to Scotland, and Alexander acknowledged him as liege lord for his possessions in England. Alexander III. was but a boy, in his eighth year, when he was crowned. After his investiture a Gaelic bard recited the genealogy of the sovereigns of Scotland, carrying back the legends of his ancestry into the midst of the mysterious myths of the antique Celtic migrations. This scenic device was evidently designed to evoke a sentiment of national unity, and to operate as a defiance to English claims. The marriage between Alexander and Margaret, which Henry had devised, took place with great splendour on Christmas, 1251, at York, in the presence of Henry and Eleanor, and Mary de Couci, queen-dowager of Scotland. When here, the boy-king did homage for his English lands; but when Henry proposed that he should do so for Scotland, he replied that he could not render such fealty except by advice and consent of the states of his kingdom. The relations between Alexander III. and Henry III. were in the main peaceful. By the defeat of Haco of Norway at Largs, 1263, Man and the Hebrides were surrendered to Scotland. Eric, son of Haco, became the husband of Alexander's daughter; and when Alexander III., at Edward's coronation, did homage as an English landholder, that astute sovereign only required that he should declare himself his "liegeman against all his enemies." No attempt was made during Alexander's life to assert any pretension to royal superiority. Alexander's queen, Edward's sister, died in 1274, her son in 1282, her daughter, Eric's wife and queen of Norway, in 1284, and Alexander III. himself—riding between Burntisland and Kinghorn in the dark night—was thrown from his horse and instantly killed, 26th March, 1286. Thus the succession devolved on "Margaret the Maiden of Norway," Alexander's grand-daughter, and grand-niece of Edward I. Edward was in France acting as umpire in regard to the crown of Sicily, and paying homage to Philip. He did not return till August, 1289. On intelligence of the death of Alexander reaching him, Edward recommended a committee of regency. At Scone, 11th April, six guardians of the realm of Scotland were chosen, viz., of the north, Fraser, bishop of St. Andrews, Duncan, earl of Fife, and Alexander, earl of Buchan; of the south, Wishart, bishop of Glasgow, Comyn of Badenoch, and James, high steward of Scotland. Rivalries almost immediately arose among those who claimed to be in the line of succession, and confederacies were formed among them to stand by each other in the event of any contingency involving the inheritance of the crown. Between the partisans of the houses of Bruce and Baliol open war was waged, and continued during Edward's absence, to ravage the country. On his return he was invited to give counsel concerning the troubles of the Scottish kingdom. He asked them to send commissioners to Salisbury, there to treat of "matters of import." Fraser, Wishart, Bruce, and Comyn were delegated. Edward proposed that Edward of Carnarvon and Margaret of Norway should be betrothed, "all the rights and laws of Scotland being fully conserved." At a conjoint meeting of English plenipotentiaries and of representatives of the Scottish estates, held at Brigham 18th July, 1290, a treaty to that effect was agreed on. This wise and prudent political compromise was, however, not destined to be realized. The Maiden of Norway fell sick on her passage to Scotland, was landed on one of the Orkney islands, and died there in her eighth year, in one of the latter days of September, 1590, and in her the line of Malcolm Canmore closed. Twelve competitors appeared as claimants of the crown, each eager to bring the decision to the sword's point. Anarchy seemed imminent. Arbitration afforded the only hope of peace. Whose interposition, as arbitrator, could men so safely seek as that of Edward the Chivalrous? To him they appealed. He accepted the umpireship, and invited the great nobles and clergy of Scotland to meet him, 10th May, 1291, at Norham Castle, by the southern waters of the Tweed. There, as a preliminary, Edward demanded that the estates should assent to his right as Lord Paramount to enforce submission to such decree as he might, after due investigation, issue. The estates demurred—they could not thus betray the rights of the crown while the throne was vacant. "By Holy Edward, whose crown I wear," he exclaimed, "I will vindicate my just rights, or perish in the attempt!" The assembly was adjourned till 2nd June. Then it met on Holywell-haugh, on the Scottish side of the Tweed, just

opposite Norham. Here the competitors agreed "to receive judgment from Edward as Lord Paramount, to abide by his decision, and to consent that he should possess the kingdom to whom he awarded it." The estates consigned to his care, 11th June, the whole lands and castles of Scotland to hold for the successful candidate, with provision that within two months after his award they should be re-delivered to Scotland's future sovereign. Then a commission, consisting of "discreet and faithful men," was constituted, whose duty it was to be to consider and report upon the contending claims. Between this time and 3rd August, Edward made a progress through Scotland, and on that day, at Berwick, received the statement of claims and heard them read. He then commanded the commission to consider them, and ordered their report to be presented on 2nd June, 1292. At that date the commission was not agreed, and Edward adjourned the case till 15th October. Balliol and Bruce were heard at Berwick, and then the assembly decided "that the more remote in one degree lineally descended from the eldest sister was preferable to the nearer in degree issuing from the second sister." In accordance with this finding on 6th November, Edward pronounced "that Bruce could take nothing in the competition with Balliol." Bruce dissented; but on 17th November, Edward decreed "that John Balliol ought to have *sasine* [*i.e.* legal possession] of the kingdom of Scotland—with reservation always of the right of the King of England and his heirs, when they shall think proper to assert it." The Great Seal of Scotland was then broken in four pieces and deposited in the Treasury of England. Next day, Balliol swore fealty to Edward. On St. Andrew's Day he was crowned at Scone, and on the day after Christmas paid homage to Edward at Newcastle-upon-Tyne.

Philip the Fair thought he might as well have a united France as Edward a united England. He summoned Edward as duke of Aquitane to answer for some petty broil which had resulted in bloodshed. Edward sent first a bishop, then his brother Edmund to negotiate. The latter agreed to the surrender of Gascony for forty days pending the pleadings. On the lapse of the forty days, Edward demanded re-infeftment and was refused. Edward, incensed, unsheathed his sword; but just then Madoc's revolt in Wales hampered his arm, and when he rode homeward victor over that prince he found Philip had made a treaty with Scotland, and that the Count d'Artois had defeated the English forces in France, and expelled from it—except in a few maritime towns—all Edward's adherents.

Bound to choose between Gascony and Scotland, Edward resolved to make sure of the latter. He summoned Balliol to acknowledge his supremacy. He, refusing, was found guilty of contempt. The barons of Scotland, while supporting Balliol, took him under tutelage, and formed a council for the management of the kingdom. When Edward called them, as his vassals, to proceed against France they did not comply, and dismissed all Englishmen from Balliol's court. The Pope released Balliol from his oath of fealty. As if to show scorn of Edward's power, the Scots cruelly harried the northern borders and besieged Carlisle. Edward, seeing in this a legal ground for retaliatory measures and enforcement of power, marched to Berwick to strike terror into every Scottish soul. That rich trading town was taken, and given over to massacre, "till the blood ran down its streets like a mill-stream." Balliol defied Edward, and he threatened a crushing humiliation. Surrey and Warwick defeated the Scots at Dunbar. The English king took Roxburgh, Edinburgh, and Stirling, and, followed by Welsh and Irish troops, went north "to see the hills of Scotland." At Brechin, Balliol abjectly sued for mercy and was sent to the Tower, whence he was subsequently dismissed to reside on his estates in Normandy. From Elgin, Edward returned by Scone, took the holy Stone of Destiny, the cross of St. Margaret, and all the royal ornaments of the nation, and sent them to Westminster. After overrunning the country he believed that he was master of a new throne. De Warenne, earl of Surrey, was named governor of Scotland; Cressingham, treasurer; and Ormesby, justiciar. He then proceeded to Flanders.

Hitherto Edward had been engaged with the Scottish peers and prelates; he had yet to deal with the people. They had been, amidst all the contentions of the feudal lords, learning to take care of themselves. Kings had been weak, and nobles powerful; but neither had been able to enforce obedience. Thus the people had been somewhat peculiarly trained to self-government, and become rather self-willed in their ways. Heavy taxation strictly levied, rigorous legislation firmly dealt out, vigorous government oppressively active, and the attempt to thrust English monks and clergy into the abbeys and benefices of Scotland excited murmur, and at last roused to resistance. The Scottish people prepared to have their say in the policy of the times. They were not quite minded to be the playthings of princes and the puppets of peers.

THE GREEK LANGUAGE.—CHAPTER VII.

CONJUGATION OF VERBS: ACTIVE, PASSIVE, AND MIDDLE—THE AUXILIARY VERB εἰμι, AND SOME SIMILAR VERBS IN μι.

THE conjugation of the Greek verb is much fuller and more intricate than the Latin verb. It seems, moreover, to bring us much nearer the etymological origin of that part of speech than the Roman language. It is highly probable, scholars think, that verbs in the Greek language were derived originally from the names of things, *i.e.* substantives. By combining these with the personal pronouns they came, in consequence of the association of ideas, to express not things, but the operations of things. The conversion of nouns into verbs might be ideally explained in the following manner. Suppose (1) the personal pronouns to have become, by frequency of use, habits of contraction, and desire of euphony, changed; as

εγω	into	ω,	I,	ἡμεις	into	ομεν,	we,
συ	"	εις,	thou,	ὑμεις	"	ετε,	ye,
ὁυ	"	ει,	he,	ὁυτοι	"	ουσι,	they.

(2) Let these, in their corrupted state, be annexed to any noun, as οινο-ς, wine, and we should have οινο-ω, wine I, οινο-εις, wine thou, οινο-ει, wine he, οινο-ομεν, wine we, οινο-ετε, wine ye, οινο-ουσι, wine they.

The attention of the speaker or hearer when fixed upon the first of these combinations—that union of the two words which signified himself and wine—could scarcely fail to bring to his mind the experience he had previously had in connection with that liquid, and hence calling up the ideas of making wine, or tasting of wine, or drinking of wine. The two terms thus combined he might naturally employ to express one or other of these notions. A similar process would take place with the remaining five combinations, and thus we should have verbs diversified by six persons. This extension of the names of things to signify the actions which those things have been observed to exert is founded on the law of association, and might be illustrated more fully by many examples:—

Noun.	Stem.	Verb.
τυπος, a stroke,	τυπ.	τυπτω, I strike.
φυγη, flight,	φυγ,	φευγω, I flee.
βαφη, a dip,	βαφ,	βαπτω, I dip.
βλαβη, an injury,	βλαβ.	βλαπτω. I injure.
ληθη, oblivion,	ληθ,	ληθω, I am hid.
ταραχη, confusion,	ταραχ,	ταρασσω, I confuse.
βελος, a shot,	βαλ,	βαλλω, I throw.
φθορη, corruption,	φθερ,	φθειρω, I corrupt.
φυλακη, a guard,	φυλακ,	φυλασσω, I guard.

After having realized the personal aspect of actions performed or operations taking place, the element of time required indication, as tense; the variety of inducing influences, as moods; and the relations of speakers to the activities moving around, as voices. Thus the complete consideration of the verb and its exhibition in the form of a paradigm require that voice, mood, tense, number, and person should be distinguished and defined.

The grammatical idea of voice is that of the speaker as (1) acting, or (2) enduring, or (3) both. The Greek verb has three voices (in this sense). The active expresses what is done, the passive what is suffered by (*i.e.* done to), and the

middle what is done or got done for, by, or in reference to oneself. Some verbs, which have their inflexions partly middle and partly passive, as δεχομαι, I accept, are called deponents.

The force of the moods in the Greek verb may be, in general terms, explained thus: Action may be regarded as (1) seen, manifested, and actual; (2) as likely or ready to be exerted on occasion arising; (3) as desirable or undesirable in certain frames of mind or conditions of things; (4) as a possession or power under the influence of the will of oneself or of others; (5) as an idea undefined in its mode of exercise; and (6) as an attribute possessed and exercised by persons or things. Hence originate the six moods or varieties of the Greek verb, viz.:—

(1) The Indicative denotes the simple state of the action in relation to the subject; as λυω, I loose.

(2) The Subjunctive expresses a conditional or contingent state of the action, generally implying a reference to the power of the subject; as λυω, I may loose.

(3) The Optative denotes, by itself, a wish or prayer; but when the granting or success of either depends upon some supposed event it becomes conditional or potential; as λυοιμι, I might loose.

(4) The Imperative indicates authority, and hence implies command; as λυε, loose.

(5) The Infinitive expresses the simple state of the act, without reference to any subject; as λυειν, to loose. This is often used as a noun substantive.

(6) The Participle has always a relation to a noun, and expresses the same time and nature of the act as the tense to which it belongs; as λυων, loosing.

The distinction between the subjunctive and the optative, which is sometimes very subtle, may be exhibited thus:—

Subj. I raise *or* will raise my arm, ἱνα τυπτω, that I may strike.

Opt. (*a*) I raised my arm, ἱνα τυπτοιμι, that I might strike.
(*b*) τυπτοιμι, might I strike [having a wish to do so].
(*c*) τυπτοιμι ἀν or κε, I might strike, possibly, *or* if I chose [as one having power to do so].

The tenses may be arranged into classes—I. Primary; II. Secondary.

The primary tenses again divide into two subclasses—viz. (1) principal or definite; (2) historical or indefinite. Of the former are (1) present, (2) future, (3) perfect. Of the latter are (1) imperfect, (2) aorist, (3) pluperfect.

The secondary are subordinate forms of the primary tenses. The future and the perfect of the one, and the aorist and the pluperfect of the other, have each two possible forms of subordinate force, called respectively first and second future, perfect, aorist, and pluperfect. In the passive voice there is a third future sometimes, called the future perfect. Every verb, however, has not these secondary tenses. The second future occurs in verbs whose roots end in a liquid. The second aorist, perfect, and pluperfect are comparatively rarely found, and these are often in transitive verbs intransitive in power and signification. The specific meaning of the tenses will be most conveniently explained in the course of an analytical examination of the paradigms to which we shall invite the student.

First Conjugation—Verbs in ω.

Verbs in ω may be classified according to the character of their verb-stem. By the use of letters in brackets we try to show the form in which the verb-stem often appears in the present and imperfect tenses. They are given to help the learner in assigning each verb to its most probable class.

Class I.—*Consonant Stems.*

(1) Labials, π, β, φ [πτ], as τυπτω, I strike, τυπ.
(2) Gutturals, κ, γ, χ [σσ, ττ], " πλεκω, I weave, πλεκ.
(3) Dentals, τ, δ, θ [ζ, σσ], " πειθω, I persuade, πιθ.
(4) Liquids and nasals, λ, ρ, μ, ν, " σπειρω, I sow, σπερ.

Class II.—*Vowel Stems.*

(1) Vowels (uncontrac.) { ι, υ. as λυω, I loose, λυ.
{ αυ, ευ, ου, " λουω, I wash, λου.
(2) " (contracted), α, ε, ο, " τιμαω, I honour, τιμα.

One of the greatest difficulties likely to be felt by the student in the conjugation of Greek verbs is that arising from the changes which require to be made in the tense-stem before affixing the personal terminations. Vowels concur with vowels and require to be contracted; consonants come into conjunction which the Greek ear felt to be discordant, and which require to be brought into conformity with harmony of sound or euphony. The following are some of the chief special requirements of the laws of euphonic change to which the student must attend in order that he may rightly change the consonants in verbs before adding the personal endings to the tense-stem. They agree with and are derived from the general rules of euphony, and are merely useful practical selections from them:—

In regard to (1) guttural and labial stems, the law may be stated thus in general terms—viz.

(*a*) Hard letters must precede hard.
(*b*) Soft " " " soft.
(*c*) Aspirate " " aspirate.

And the immediate results may be tabularly set forth thus:—

Before σ { Labials [π, β, φ] become π, and form ψ, as τυψω.
{ Gutturals [κ, γ, χ] " κ, " ξ, " πλεξω.
" θ { Labials become φ, as ἐτυφθην.
{ Gutturals " χ, " ἐπλεχθην,
" μ { Labials " μ, " τετυμμαι.
{ Gutturals " γ, " πεπλεγμαι.
" τ { Labials " π, " τετυπται.
{ Gutturals " κ, " πεπλεκται.

(2) Dental [*i.e.* τ, δ, θ] stems. The law regarding these is twofold—viz. (*a*) dentals are dropped before σ or κ; as πεισω, πεπεικα; (*b*) before any other consonants they become σ; as ἐπεισθην, πεπεισμαι.

(3) Liquid and nasal stems. As regards these stems, we can only usefully note these two regulative facts—viz. (*a*) liquids [λ, ρ] require no change; (*b*) nasals [ν, μ] are very irregularly treated, but ν is usually dropped before σ, θ, μ, τ, κ. From φαινω (of which the stem is φαν), however, we have πεφανσαι, ἐφανθην, πεφασμαι, πεφανται, πεφαγκα.

(4) Three consonants cannot be allowed to come together, unless either the first or last of them is a liquid; hence τετυπσθαι requires the elision of σ, and the soft mute π is aspirated to agree with the aspirate θ=τε-τυφ-θαι.

With special reference to the nasal ν these rules hold:—Before a *p* sound (or ψ) ν becomes μ; before a *k* sound (or ξ) γ; before a liquid that liquid; before σ or ζ it is generally elided, but it is retained before σαι in the perfect passive.

The following paradigm of a consonant verb of the First Conjugation presents the first person of each tense (1) in all the voices, and (2) in all the moods.

It will be found in our subsequent dealing with the Greek verb that many of the person-endings of the tenses are precisely similar, and that having learned the terminations of one set of them it is quite easy to add these to the tense forms given in the paradigm, which supplies in a condensed fashion every possible part of the verb, and forms in reality a type of conjugation.

ACTIVE VOICE.

Τυπτω, I strike.

Simple verb-stem τυπ, from τυπος, a blow.

Present, τυπτω; First Future, τυψω; Perfect, τετυφα.

	Indic.	Imper.	Optat.	Subj.	Infin.	Part.
Pres.	τυπτω	τυπτε	-οιμι	-ω	-ειν	-ων
Imperf.	ἐτυπτον					
1st Fut.	τυψω		-οιμι		-ειν	-ων
2nd Fut.	τυπω		-οιμι		-ειν	-ων
1st Aor.	ἐτυψα	τυψον	-αιμι	-ω	-αι	-ας
2nd Aor.	ἐτυπον	τυπε	-οιμι	-ω	-ειν	-ων
Perf.	τετυφα	τετυφε	-οιμι	-ω	-εναι	-ως
Pluperf.	ἐτετυφειν					

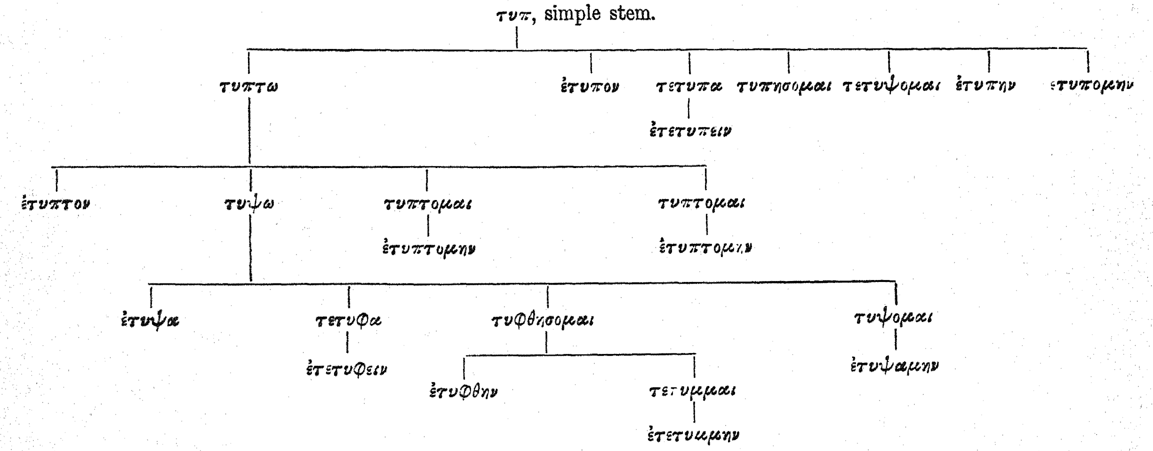
PASSIVE VOICE.

	Indic.	Imper.	Optat.	Subj.	Infin.	Part.
Pres.	τυπτομαι	τυπτου	-οιμην	-ωμαι	-εσθαι	-ομενος
Imperf.	ἐτυπτομην					
Perf.	τετυμμαι	τετυψο	-μμενος -εἱην	-μμενος -ὠ	-φθαι	-μμενος
Pluperf.	ἐτετυμμην					
1st Aor.	ἐτυφθην	τυφθητι	-θειην	-θω	-θηναι	-θεις
2nd Aor.	ἐτυπην	τυπηθι	-ειην	-ω	-ηναι	-εις
1st Fut.	τυφθησομαι		-οιμην		-εσθαι	-ομενος
2nd Fut.	τυπησομαι		-οιμην		-εσθαι	-ομενος
3rd Fut.	τετυψομαι		-οιμην		-εσθαι	-ομενος

MIDDLE VOICE.

	Indic.	Imper.	Optat.	Subj.	Infin.	Part.
Pres.	τυπτομαι	τυπτου	-οιμην	-ωμαι	-εσθαι	-ομενος
Imperf.	ἐτυπτομην					
Perf.	τετυπα	τετυπε	-οιμι	-ω	-εναι	-ως
Pluperf.	ἐτετυπειν					
1st Fut.	τυψομαι		-οιμην		-εσθαι	-ομενος
2nd Fut.	τυπουμαι		-οιμην		-εισθαι	-ουμενος
1st Aor.	ἐτυψαμην	τυψαι	-αιμην	-ωμαι	-ασθαι	-αμενος
2nd Aor.	ἐτυπομην	τυπου	-οιμην	-ωμαι	-εσθαι	-ομενος

Having read this paradigm over several times very carefully, the student should learn to trace the formation of part from part. To aid him in this task, which requires principally an attentive mind and an observant eye, we put before him a very clear and simple expository chart of the formative derivation of each part of the verb, from the simple stem to the most complex form it takes:—



The verbs in these lists are chosen with the view of giving the beginner practice in the rules for the change of consonants. Present-stems in σσ may be taken as belonging to the guttural class, those in ζ to the dental, and those in πτ to the labial.

EXERCISES.

Look carefully over the paradigm, and beside each form in the foregoing chart write a figure which will indicate its place in conjugation.

Draw out (1) a similar table of the following verbs; (2) write out any three in the form of the foregoing paradigm:—

ἀμειβω, ἀμειψω, ἠμειψα, to change.
ἁπτω, ἁψω, ἡψα, ἡμμαι, ἡφθην, to fasten, kindle.
βλαπτο, βλαψω, βεβλαφα, βεβλαμμαι, ἐβλαφθην, ἐβλαβην, to hurt.
βλεπω, βλεψω, βεβλεφα, ἐβλεψα, to see.
γραφω, γραψω, γεγραφα γεγραμμαι, ἐγραφθην, to write.
θαπτω, θαψω (τεθαφα), τεθαμμαι, ἐθαφθην, ἐταφην. to bury.
καλυπτω, καλυψω, κεκαλυφα. κεκαλυμμαι, ἐκαλυφθην, εκαλυβην, to cover.
κοπτω, κοψω, κεκοφα, κεκομμαι, ἐκοφθην, ἐκοπην. to cut.
κρυπτω, κρυψω, κεκρυφα. κεκρυμμαι, ἐκρυφθην, εκρυβην, to hide.
λειπω, λειψω (λελειφα), λελειμμαι, ἐλειφθην, ἐλιπον, λελοιπα, to leave.
ῥιπτω, ῥιψω, ἐῤῥιφα, ἐῤῥιμμαι, ἐῤῥιφθην, to throw, cast.
τερπω, τερψω, ἐτερφθην, ἐταρπομην, to delight.
τρεπω, τρεψω. τετροφα, τετραμμαι, ἐτρεφθην, ἐτραπην, to turn.
τρεφω, θρεψω, τετροφα. τεθραμμαι, ἐθρεφθην, ἐτραφην, to nourish.
τριβω, τριψω τετριφα, τετριμμαι, ἐτριφθην, ἐτριβην, to rub.
σκωπτω, σκωψω, ἐσκωψα, ἐσκωμμαι, ἐσκωφθην, to mock.

As the substantive verb *εἰμι*, I am, with *εἶμι*, I am going, contains in form many of the inflexions of every Greek verb, and parts of it are joined (especially by the Attic writers) to the participles of the perfect active and passive, it is here placed first in the order of paradigms and examples, rather than, as it is commonly, after verbs of the conjugation in *μι*. A knowledge of its inflexions will greatly facilitate the learner's study of all subsequent verbal paradigms.

The verb *εἰμι* is one of the verbs in *μι*, but is irregularly declined. All its existing tenses are formed from the stem *εσ* (Lat. *es-um* or *sum*). Its other tenses may be supplied from the stems *φυω*; as aorist, *εφυν*, I was, perfect *πεφυκα*, I am (Lat. *fui*, *fuero*).

εἰμι, I am, *εσομαι*.

INDICATIVE MOOD.

PRESENT, I am.

Sing.,	*εἰμι*, I am	*εἱς* or *εἰ*, thou art	*εστι (ν)*, he is.
Dual,	—	*εστον*, ye two are	*εστον*, they two are.
Plur.,	*εσμεν*, we are	*εστε*, ye are	*εἰσι (ν)*, they are.

IMPERFECT, I was.

Sing.,	*ἠν*	*ἡς* or *ἠσθα*	*ἠ* or *ἠν*.
Dual,	—	*ἠτον (ἠστον)*	*ἠτην (ἠστην)*.
Plur.,	*ἠμεν*	*ἠτε (ἠστε)*	*ἠσαν*.

IMPERFECT (MIDDLE), I was, *or* were I (*little used*).

Sing.,	*ἠμην*	*ἠσο*	*ἠτο*.
Dual,	*ἠμεθον*	*ἠσθον*	*ἠσθην*.
Plur.,	*ἠμεθα*	*ἠσθε*	*ἠντο*.

FUTURE (MIDDLE), I shall be.

Sing.,	*εσομαι*	*εσῃ*	*εσεται*, cf. *ισται*.
Dual,	*εσομεθον*	*εσεσθον*	*εσεσθον*.
Plur.,	*εσομεθα*	*εσεσθε*	*εσονται*.

Subjunctive Mood.

PRESENT AND IMPERFECT, I may be.

Sing., ὠ	ᾐς	ᾐ.
Dual, —	ἠτον	ἠτον.
Plur., ὠμεν	ἠτε	ὠσι (ν).

Optative Mood.

PRESENT AND IMPERFECT, I might be.

Sing., ειην	ειης	ειη.
Dual, —	ειητον	ειητην.
Plur., ειημεν	ειητε	ειησαν or ειεν.

FUTURE (MIDDLE), I might be about to be.

Sing., εσοιμην	εσοιο	εσοιτο.
Dual, εσοιμεθον	εσοισθον	εσοισθην.
Plur., εσοιμεθα	εσοισθε	εσοιντο.

Imperative Mood.

PRESENT AND IMPERFECT, be.

Sing., —	εσο (ἰσθι)	εστω.
Dual, —	εστον	εστων.
Plur., —	εστε	εστωσαν.

Infinitive Mood.

PRESENT and IMPERFECT, ειναι, to be,
FUTURE (MIDDLE), εσεσθαι, to be about to be.

Participles.

PRESENT and IMPERFECT, being; N. ὠν, ουσα, ὀν, G. ὀντος, &c.
FUTURE (MIDDLE), about to be, N. εσομενος, η, ον, &c.

ACTIVE VOICE.

εἶμι, I shall go.

As this verb, in several of its parts, differs from ειμι, I am, only by its accent and a subscript *iota*, it will be well to have it available for ready comparison. It is derived from a stem, ἰ, which appears in Latin *ire*, to go, from obs. ιμι.

Present Indicative.

Sing., ειμι	εἰς or ει	εἰσι.
Dual, —	ἰτον	ἰτον.
Plur., ἰμεν	ἰτε	ἰασι.

Imperfect or 2nd Aorist, he went, &c.

Sing., ιον	ιες	ιε (ν)
Dual, —	ιτον	ιτην.
Plur., ιμεν	ιτε	ισαν.

2nd Plural.

Sing., ᾐειν	ᾐεις	ᾐει.
Dual, —	ᾐειτον	ᾐειτην.
Plur., ᾐειμεν	ᾐειτε	ᾐεισαν or ᾐεσαν. Ion. ᾐισαν.

Middle Voice.

IND. FUTURE, εισομαι — εισῃ, &c. } not Attic.
1st AOR. εισαμην — εισω, &c. } not Attic.

Subjunctive, I may go.

Sing., ἰω	ἰῃς	ἰῃ.
Dual, —	ἰητον	ἰητον.
Plur., ἰωμεν	ἰητε	ἰωσι.

Optative, I might go.

Sing., ἰοιμι	ἰοις	ἰοι.
Dual, —	ἰοιτον	ἰοιτην
Plur., ἰοιμεν	ἰοιτε	ἰοιεν.

Imperative, go thou.

Sing., —	ἰθι	ἰτω.
Dual, —	ἰτον	ἰτων.
Plur., —	ἰτε	{ ἰτωσαν, ἰτων, and ἰοντων.

Infinitive, ιεναι, to go.

VERBAL ADJECTIVES, it is necessary to go. — PARTICIPLE, having gone.

Mas., ιτος.	ιων	{ G. ιοντος, cf. *euntis* in Latin. } &c.
Fem., ιτεος.	ιουσα	
Neut., ιτητεον.	ιον	

The present of ειμι has the force of the future, I will go, in the Attic writers; ᾐα and ᾐειν are used not in the sense of the perfect and pluperfect, but of the aorist and imperfect; εισομαι and εισαμην occur in this sense in the epic poets only.

From the same root with ειμι is formed ιημι, I go, which is used only in a few persons; as present, ιησι, he goes; imperfect, ιεσαν, they went; optative, ιειη, he might go; participle, ιεις, ιεντες, going; and in the middle voice—present indicative, ιεμαι, ιεσαι, ιεται, &c.; imperfect, ιεμεν, ιεσο, ιετο, &c.; imperative, ιεσο, ιεσθω, &c.; infinitive, ιεσθαι; participle, ιεμενος.

EXERCISE.—Arrange a form thus; look carefully through the conjugation of εἶμι, and state the mood, tense, number, and person of the following parts of it:—

Verb.	Mood.	Tense.	Number.	Person.
'Εσοιο.	Optative.	Future Middle.	Singular.	Second.

ισθι, εσοιμεθα, εσμεν, εσομεθα, εσοιμεθον, εις, εσται, ᾐς, ᾐσαν, ᾐντο, εστων, εσοιντο, εσοισθην, εσῃ, ειεν, ειη, ᾐτε, ὠμεν, ᾐμεν, ουσα, ουσων, ὀν, εισι, ὠσι, ειτην, εστω, εσομενων, ᾐς, εστοσαν.

EXERCISE IN READING.

Simple Sentences from the Greek Dramatists.

The student is recommended to read these sentences carefully; to turn to the declensions and endeavour to find the cases of the nouns occurring in them; and to run over the whole of the cases. If he commit the passages to memory he will enlarge his vocabulary.

'Οργης ματαιοι γε εισιν αιτιαι λογοι, Foolish words are indeed the fuel of anger.

'Αει το σιγαν εστι φαρμακον βλαβης, Silence is ever a medicine for mischief.

'Ηβης το γηρας εστιν ευδικωτερον, Old age is more impartial than youth.

'Ανθρωπος εστι πνευμα και σκια μονον, Man is a breath and but a shadow.

'Εστ' ελπις η βοσκουσα τους πολλους βροτων, Faith is the food of many men.

Ει σωμα δουλον, αλλ' ὁ νους ελευθερος, Thou body art a slave, but mind is free.

Τις ποτ' εσθ' ὁς ουχ αυτω φιλος, Who is there who is not a friend to himself?

Κριτικωτερα δητ' ὀψις εστι ὠτων πολυ, Eyes are by far more critical than ears.

Θεος τις εστ' εν ἡμιν, There is a God within us.

Ουκ εστιν ὀυδεν χαρις ανθρωποις Θεου, There is (happeneth) to man nothing independently of God.

Κρειττων το μη ζην εστιν ἡ το ζην κακως, It is better not to live than to live ill.

Τις εστι δουλος του θανειν αφροντις ὠν, Is he a slave who fears not to die?

Τυραννιη ειναι θεων βιος νομιζεται, Tyranny means to be (have) the life of the gods.

'Εστιν τι κερδος εν κακοις αγνωσια, What an advantage is ignorance of wickedness!

Το νικαν εστι παν ευβουλια, Good counsel is the best of all conquerors.

'Αδυνατα τολμαν ανδρος ουκ εστιν σοφου, The impossible is not the courage of a wise man.

ENGLISH LITERATURE.—CHAPTER IX.

SIDNEY — SPENSER — SOUTHWELL — SYLVESTER — DAVIES OF HEREFORD — SIR JOHN DAVIES — DONNE — NICCOLS — WARNER, AND OTHER MINOR POETS.

As Chaucer has been called the "Day-star," Spenser has been styled the "Sunrise" of English poetry. Milton describes him as "sage and serious;" Charles Lamb names him "the poet's poet." His allegory itself, as Leigh Hunt says, "is but one part allegory and nine parts beauty and enjoyment," communicated in verse fit to "make heaven drowsy with the harmony." "Spenser's poetry," Hazlitt declares, "is all fairyland," and a whole *chorus vatum* might be quoted singing the same refrain. He rose, it might be said, amid a blaze of stars. The life of one of these was a romance more poetical than his poetry, and as noble as his prose—Sir Philip Sidney, Spenser's chief friend, who in camps, courts, revels, loves, statecraft, and war could keep a living heart and pour forth the emotions of it in rich, ripe, luscious, and quick verse.

> "Arcadian Sidney! nurseling of the Muse,
> Flower of fair chivalry, whose bloom was fed
> With daintiest Castaly's most silver dews,
> Alas! how soon thy amaranth leaves were shed!
> Born what the Ausonian minstrel dreamed to be,
> Time's knightly epic passed from earth with thee."

He was born at Penshurst, Kent, 29th November, 1554, and named after Philip of Spain, Queen Mary's husband. Sir Henry Sidney, his father, was lord president of Wales, and Philip's boyhood was spent in Ludlow Castle. He was schoolfellow with Lord Brooke at Shrewsbury, whence he went to Christ Church, Oxford. Queen Elizabeth licensed his going abroad in 1572, and Charles IX. made him one of the gentlemen of his chamber. On St. Bartholomew's Eve he was the guest of Sir Francis Walsingham, and so escaped the massacre. After travelling through Europe, he was introduced at court in 1575 by Leicester. At Chartly Castle he met the brilliant beauty, Penelope Devereux, afterwards Lady Rich. Then began his poetical existence; as Spenser says—

> "To her he vowed the service of his dayes,
> On her he spent the riches of his wit,
> For her he made hymns of immortal praise,
> Of only her he sung, he thought, he writ:
> Her, and but her, of love he worthy deemed:
> For all the rest but little he esteemed."

The "Astrophel and Stella" romance was sadly brought to a crisis by Stella's marriage with Lord Rich in 1581. In that year Astrophel entered Parliament. In January, 1583, he was knighted; in March he married Frances, daughter of Secretary Walsingham, and he was afterwards appointed governor of Flushing. His father died 5th May, and about three months afterwards Lady Mary Sidney died also. On 22nd September, at Zutphen, near Coleston-dike, on the Yssel, "he received a musket shot a little above the knee, which so brake and rifted the bone" that he died 17th October, 1586. His remains were brought to London and interred in St. Paul's, 16th February, 1586–87. He is the Sir Calidore (finely gifted) knight of courtesy in Spenser's "Faerie Queene" (vi.) Besides his many fine occasional poems, we owe to him the chivalric and pastoral romance "Arcadia" (1580), and an excellent "Defence of Poesie" (1583).

Edmund Spenser is a name to which there is no rival among allegorical poets. He was probably of Lancashire descent, and born about 1552 in East Smithfield. He speaks of

> "Merry London, my most kindly nurse,
> That to me gave this life's first native source."

Though belonging to "a house of ancient name," Dr. Grosart has shown the likelihood of his father having been a "free journeyman" of the Merchant Taylors' Company, of whose school—opened 1561, under the famous Richard Mulcaster —he was one of the first foundationers. Thence Spenser passed to Pembroke Hall, Cambridge, where he graduated B.A. in 1572–73, and M.A. in 1576. Hence he sings of

> "My mother Cambridge, whom as with a crowne
> He [*i.e.* the Ouse] doth adorn, and is adorned of it
> With many a gentle muse and many a learned wit."
> —"*Faerie Queene*," iv., xi. 26.

After leaving Cambridge he went to reside for a time among his relatives in North-east Lancashire (Hurstwood and Pendle), and fell under passion's power—unrequitedly :—

> "Love they him called that gaven me checkmate,
> But better mought they have behote" [=named him hate].

By Sir Philip Sidney's influence apparently, Spenser was appointed secretary to his father, Sir Henry Sidney, lord-deputy in Ireland in 1577; but Sir Henry was recalled next year, and his secretary's services were transferred to Sidney's brother-in-law, Leicester. He was, probably, at this time introduced at Court and rather contemptuously treated by Burleigh. On 5th December, 1579, "The Shepheard's Calendar" was entered at Stationers' Hall. Dryden declared this a poem of its kind "not to be matched in any language."

In 1580 Arthur Lord Grey of Wilton was appointed lord-deputy of Ireland, and engaged Spenser as his secretary. They reached Dublin on 12th August, and were at once in the midst of rebellion and pacification, turbulence and savagery, collision and checkmate. From Lodowick Bryskett, who wished "to withdraw to the quietness of study," Spenser "purchased" the appointment of clerk of the Court of Chancery, 22nd May, 1581.

Bryskett tells us that Spenser had said, "I have already undertaken a work . . . in heroical verse, under the title of a 'Faerie Queene,' to represent all the moral virtues, assigning to every virtue a knight to be the patron and defender of the same, in whose actions and feats of arms and chivalry the operations of that virtue, whereof he is the protector, are to be expressed, and the vices and unruly appetites that oppose themselves against the same, to be beaten down and overcome. Which work I have already well entered into." This was in 1582–83, after Lord Grey had been recalled. He was, in all probability, resident in Dublin (where he had the lease of a house for six years), attending to his duties, and then he obtained the office of clerk of the Council of Munster, and bought from "one Reade" a grant of 4000 acres of land at Kilcolman, under condition that it should be colonized and cultivated. Kilcolman Castle, 3 miles from Doneraile (formerly the residence of the Desmonds), became his home. There Sir Walter Raleigh visited him in 1589, had read to him parts of the poem, was in ecstasies, and insisted on his going to Court, where "The Shephearde of the Ocean" so interested himself in winning the queen's favour for Spenser's poems

> "That shee thenceforth therein 'gan take delight,
> And it desired at timely houres to heare."

On 1st December, 1589, the "Fayre Queene, dysposed into xij bookes," &c., was entered at Stationers' Hall, and the first three books appeared in 1590, dedicated "to the most mightie and magnificent Empresse Elizabeth," as

> "Goddess heavenly bright,
> Mirror of grace and majestie divine,
> Great Lady of the Greatest Isle, . . .
> The argument of mine afflicted style."

A letter to Raleigh expounding the author's intention, as well as commendatory poems and sonnets addressed by the author to many of the most honourable and excellent noblemen and ladies of the court, were affixed. Raleigh says:

> "Of me, no lines are loved nor letters are of price,
> Of all which speak our English tongue, but those of thy device."

The charming sweetness of its verse made the poem popular at once. Before the year closed the publisher had arranged for and entered, 29th December, 1590, a book entitled "Complaints," and a patent for a pension of £50 per annum was issued in February, 1591, by order of the queen. On 1st January, 1591-92, he wrote, in London, the "Epistle Dedicatorie" to Daphnaida, which was immediately published; but he sends "from my house of Kilcolman the 27th December, 1591," to Raleigh, that he might see that he is "not always idle," "Colin Clout's Come Home Againe"—a very real and yet richly poetical "verse-diary" of his visit to, experience in, and return from London—though it was first published (revised) in 1595. Meanwhile, several of his minor poems having apparently

been left in the publisher's hands, and notes of where others might be had, the printing of the "Complaints" went on, and when enough had been got to make a volume it was issued. The "little man, who wore short haire, little band, and little cuffes" (as Aubrey, on Christopher Beeston's authority, describes the outward accidents of the poet), in his *Amoretti* supplies a picture of his inner nature, and therein shows that he was indeed "a noble man of perhaps the noblest of ages." In these we can trace the course of his true love, till, 11th June, 1594, in the cathedral of Cork, Elizabeth Boyle of Kilcoran became his wife, and he composed her bright and radiant "Epithalamium." These love-sonnets and that marriage-song he took the opportunity (slyly) of sending, through Sir Robert Needham, to press. They appeared in 1595, and made most likely an acceptable gift-book to her whom they celebrate.

On his marriage Spenser resigned his clerkship of the Council of Munster, enjoyed the rich felicity of well-found love, and continued to apply himself to his poetical tasks. Shortly after the birth of his first son, Sylvanus, he was able to carry with him to London the MS. of "The Second parte of the ffaery Queene, conteninge the 4, 5, and 6 bookes," as it was entered, 20th January, 1596; and while in London, prior to being present as an invited guest at the double wedding of the Ladies Elizabeth and Catherine Somerset to "Henry Gilford and William Peter, Esquyers," prepared a "Prothalamion," which was probably first privately printed, and then issued to gratify the noble friends of the three families. On the issue of the "Faerie Queene" (1596), James VI. complained to Queen Elizabeth against "Edmund Spenser for having published some dishonourable effects (as the king deemeth) against himself and his mother deceased" (v. ix.), and requested that he should be duly tried and punished. Spenser wrote, in England, in 1596, probably at Greenwich, his "View of the Present State of Ireland," and shorty after recrossed the sea to Kilcolman, to a home over which the lava-floods of rebellion had rushed, and under and around which the volcanic fires were not by any means exhausted, for Tyrone's rebellious ways took form in 1594. He began again his unfinished "Faerie Queene," and, having scanned "the ever-whirling wheel of change" which "all mortal things doth sway," was pouring into verse his sense of

> "How mutabilitie in them doth play
> Her cruel sports to many men's decay" [=ruin].

On 13th April, 1598, the "View of Ireland" was entered for publication, but on some ground restrained. By Elizabeth's royal letters Spenser was appointed sheriff of Cork, 30th September, 1598, when the executive had been warned of "a universal Irish war, intended to shake off all English government," and Tyrone had sent his marauders into Munster. The insurgents held the province. Kilcolman Castle was set in flames. Spenser and his household escaped in haste, and rushed to Cork, where, "out of the ashes of desolation and wasteness," he wrote "to the queene" an account of the rising, and suggested "certaine pointes to be considered of in the recovery of the Realme of Ireland." On 9th December Sir Thomas Norreys sent, by Mr. Spenser, a report wherein he "manifested the misery of this countrey." By the 24th the poet and his family had arrived in London, delivered his dispatches and his "pointes" to the secretary of state. Then, writing 17th January, 1599, John Chamberlain informs Sir Dudley Carleton, that "Spenser the poet, who lately came from Ireland, died at Westminster last Saturday," *i.e.* 16th January. His illness must have been short and his end sudden. He was interred, Camden says, "in Westminster [Abbey], not far from Chaucer, at the Earl of Essex's charge. His hearse was attended by the gentlemen of his faculty, who cast into his tomb some funeral elegies and the pens they were wrote with."

"The Faerie Queene" is the most exquisite specimen of that romantic poetry which hall, bower, and farm-fireside delighted in. In its purity, nobleness, freshness, and salutary morality it is of the first rank. The imaginative ideality displayed in the management of the melodiously-worded allegory is quite exceptional. The descriptive diction he employs, the dramatic insight into character he displays, the quaintly-set-forth metaphysical ideas he presents, the fine suffusive religiousness of the poem, are all alike his own. Human language has scarcely ever been made so meltingly mellifluous and so signally significant, yet kept so human and homely. Can anything be more finely simple and tenderly true of touch than the former, or more suggestively realistic and yet conceitful than the latter of the following examples:—

> "My true-love hath my heart and I have his,
> By just exchange unto the other given;
> I hold his deare and mine he cannot misse;
> There never was a better bargain driven:
> My true-love hath my heart and I have his.
>
> "His heart in me keepes him and me in one;
> My heart in him his thoughts and senses guides;
> He loves my heart, for once it was his own,
> I cherish his because in me it bides:
> My true-love hath my heart and I have his.

THE RESIDENCE OF MEMORY.

> "That chamber seemèd ruinous and old,
> And therefore was removèd far behind;
> Yet were the walls that did the same uphold
> Right firm and strong, though somewhat they declin'd;
> And therein sat an olden man half blind,
> And all decrepid in his feeble corse,
> Yet lively vigour rested in his mind,
> And recompensed him with a better scorce:
> Weak body well is chang'd for mind's redoubled force.
>
> "This man of infinite remembrance was,
> And things foregone through many ages held,
> Which he recorded still as they did pass,
> Nor suffer'd them to perish through long eld,
> As all things else, the which this world doth weld,
> But laid them up in his immortal scrine,
> Where they for ever incorrupted dwell'd;
> The wars he well remembered of King Nine,
> Of old Assaracus and Inachus divine.
>
> "The years of Nestor nothing were to his,
> Nor yet Methusalem, though longest liv'd;
> For he remember'd both their infancies:
> Nor wonder, then, if that he were depriv'd
> Of native strength, now that he them surviv'd.
> His chamber all was hung about with rolls,
> And old records from ancient times deriv'd,
> Some made in books, some in long parchment scrolls,
> That were all worm-eaten, and full of canker holes."

Of Spenser's extraordinary variousness of power, exhibited in poems of many differing kinds and styles, no quotations could convey a notion. Southey rightly celebrates him as

> "Sweet Spenser—sweetest bard! yet not more sweet
> Than pure was he; and not more pure than wise,
> High priest of all the Muses' mysteries!"

Robert Southwell, third son of Richard Southwell of Horsham, St. Faith's, Norfolk, and of his wife Bridgette, daughter of Sir Roger Copley of Roughway, Sussex, was born about 1561. He was educated at Douay, and in his fifteenth year was transferred to Paris, where he was placed under the care of Father Thomas Darbyshire, who had been Archdeacon of Essex, and was one of the first Englishmen who joined the Society of Jesus. Influenced by him, Southwell entered the English College at Rome, and there he was enrolled among the children of Loyola, and consecrated his life to the carrying of the creed of the crucifix through his native land. He was passionately fervent and zealous, devoted to study and sanctity. In the summer of 1584 he was ordained a priest. Southwell presented a petition to Acquiviva, general of the Jesuits, craving the perilous privilege of forming one of the band of missionaries by whom the comfort and solace of Holy Church were ministered to the Catholic families of England. It was granted. In May, 1586, he left Rome, and in August came unto his own in kindred and faith. Here, with the elastic cunning of his order, under many disguises, and in the midst of many dangers, he performed his difficult duties with diligence, and by his prudent, pious, meek, and exceedingly winning ways, acquired

love, reverence, and influence. The strange sweet saintliness of his spirit overflowed into sanctified song, and among the noble families of Vaux, Arundel, and Sackville, who had poetic proclivities, this sign of a gracious genius gave added effectiveness to his ministrations. Many of his poems appear to have been printed at a private press worked in his own house in London, and dexterously distributed among the populace. In the hope of attracting them to a higher and holier love than that of which poets mostly sung, and in the belief that "the best course to let them see the error of their works is to weave a new webbe in their owne loome," he proceeded to show "how well verse and vertue suite together" in lines like these—

"Ah sinne! the no-thinge that all things defile,
Outcast from Heaven, earth's curse, the cause of Hell;
Parent of Deathe, authour of our exile,
The wrecke of soules, the wares that fiendes doe sell;
Wrong of all rights, self-ruine, roote of evils,
That men to monsters turns, angels to devils."

His prose writings include "Comforte to those in Durance for the Catholike Faith," "A Short Rule of Good Life," "The Triumphs over Deathe," and "Mary Magdelen's Funeral Teares," a fervent, striking, suggestive, morbidly sentimental, St.-Bernard-like work. His longest poem is "St. Peter's Complaint," a succession of studies on the sad incident of the "Denial of the Divine One," containing many terse line-lengths of exquisite thought. Peter describes himself as—

"A sorrie wight, the objecte of disgrace,
The monument of feare, the map of shame,
The mirrour of mishap, the staine of place,
The scorne of time, the infamy of fame.

. . . .

Ah wretch! why was I named sonne of a dove [*i.e.* Bar-jona]
Whose speeches voyded spight and breathéd gall!
No kin am I unto the bird of love,
My stony name much better suites my fall;
My oathes were stones, my cruel tongue the sling,
My God the mark at which my spight did fling.

. . . .

Titles I make untruths; am I a rock [*i.e.* Cephas]
That with so soft a gale was overthrowne?
Am I fit pastor for the faithful flocke,
To guide their soules that murdered this mine owne?
A rock of ruine, not a rest to stay,
A pastor not to feede, but to betray."

It is in his shorter poems that Southwell shows himself a saintly singer sweet and true. His occasional verses are really "exquisite labours," charmingly exhibiting care, taste, and purity of material, being indeed like "choice beads in a string of pearls." Few things are finer than "Time goes by Turns," "Lewd Love is Loss," "Scorn not the Least," "A Chylde my Choice," and "The Burning Babe." Southwell's life and poetry are alike suffused with the spirit of Castaly and Christ. He was betrayed, apprehended "by trick and deceit," imprisoned three years "in a dungeon foul and filthy," thirteen times tortured, and at last, "without any previous warning to prepare for his trial," on 22nd February, 1594, hurried to Westminster, put to the bar, condemned, and on the next morning drawn from Newgate to Tyburn, and there hanged, bowelled, and quartered, when he was (to use his own words) "about the same age as our Saviour, namely, thirty-three."

The "silver-tongued" Joshua Sylvester, though the son of Richard Sylvester, a clothier in the city of London, was born, 1568, most probably at Hadley, as he says—

"Our silver Medway (which doth deep indent
The flowerie meadowes of my native Kent"), &c.

He seems to have lost both parents while young, and to have been "cared for by his never-sufficiently-honoured dear uncle, W. Plumb, Esq., of Eltham." In his ninth year, 1573, he was enrolled in Southampton School, and became a boarder with the head-master, Dr. Hadrianus Saravia. Here he remained till Saravia, in 1576, removed to Leyden. After these "three poor years"—transferred "from *arts* to *marts*"—he was bound apprentice, probably with some relative, as a merchant adventurer. "When thrice-seven summers he had seen," "the Cyprian Queen's blinde boy," when he was "dulled with the busie toil of cities," made him taste the "delightful joy" of love. Though the lady returned his affection her friends were unfavourable. His after-years were full of sorrowful struggle. He complains of

"Time's ungrateful cruelty,
My household cares, my health's infirmity,
My drooping sorrows for (late) grievous losses,
My busie suits and other bitter crosses,"

as "the clogs that weigh down heavily my best endeavours" and hold him under "the tyrant Need." After James' accession Prince Henry received him as a visitor at court, and bestowed a small pension on him; but this ceased on his patron's death, 5th November, 1612, which was a national loss, but he says—

"More than most to me, that had no prop
But Henry's hand, and, but in him, no hope;"

for William Plumb, Esq., had died in 1593, and probably liking not his sister's son's preference of arts to marts, left him unremembered in his will and unhelped by his wealth. He had by this time married Miss Mary, sister of Robert Hill, D.D., minister of St. Bartholomew the Less, London. He was "Secretary to the English Company of Merchant adventurers at Middleburgh," and had in that capacity to travel a good deal, for he asks mournfully—

"Shall I still be Boreas' tennis-ball—
Shall I be still stern Neptune's tosséd thrall?"

Unwishful he to die in "fell Brasille," "golden Peru," or "rich Cathay," he earnestly prays that his "dear Albion,"

"Europe's pearl of price,
The world's rich garden, earth's rare paradise,
. . . . . . Will not suffer age
To snow my locks in foreign pilgrimage.

. . . .

Thou gavest me cradle, thou wilt give me hearse."

But his desire was not granted. On 28th September, 1618, Henry Peacham, in his "Truth of our Times," tells us "Joshua Sylvester, admired for his translation of 'Du Bartas,' died at Middleburgh, a factor for our English merchants, having had very little or no reward at all."

"The divine, soul-pleasing Sylvester," has had the fame of his own effusions overshadowed by his translations of the works of that "miracle of men," as he calls Guillaume de Salluste du Bartas of Armagnac—soldier, statesman, and poet (born 1544, and died—from wounds received in the battle of Ivry, which he, however, lived to celebrate in verse—in 1599). Yet he was justified in thinking that he had, "besides du Bartas," sung

"Some native strains the gravest might have read."

Of his original poems, the "ill-shapen shadows of my young delights," this may be taken as a specimen:—

"I weigh not Fortune's frown or smile,
I joy not much in earthly joyes,
I seek not state, I reck not style,
I am not fond of Fortune's toyes;
I rest so pleased with what I have,
I wish no more, no more I crave.

"I quake not at the thunder's crack,
I tremble not at noise of warre,
I swoon not at the newes of wrack,
I shrink not at a blazing starre;
I feare not losse, I hope not gaine,
I envie none, I none disdaine.

. . . .

"I feigne not friendship when I hate,
I fawne not on the Greate (in show),
I prize, I praise, a meane estate,
Neither too lofty nor too lowe;
This, this is all my choice, my cheere,
A minde content, a conscience cleere."

For nicety of epithet and happy choice of phrase, few even of the finest poets excel Sylvester. He speaks of echo as "a speaking fiction of a mocking fairy;" of lips, "two

moving leaves of coral soft and sweet;" of "the honey of care-charming sleepe;" of spiders, "that with curious pain weave idle webs and labour still in vain;" of "a ghoste with unperceived foote;" of "the lightning splendour of God's glorious eyes;" of Christ, "Him that in Him doth all the world enfold," &c. He is also remarkable for condensed proverb-like, pithy expressions — *e.g.* "Small griefs speake, but great are dumbe;" "Doing well is more than saying so;" "Virtue alone gives men eternity;" "Patience is the crest of fortitude;" "Rash revenges never want repentance;" "Valiant minds despise a victory wherein no glory lies;" "Wit lasts an age and beauty but a season," &c. Sylvester was highly valued by Spenser, Daniel, Bacon, Jonson, Hall, &c., and was gratified by their recognition.

> "'Tis best praiseworthy to have pleased the best,
> This we endeavour and defy the rest."

John Davies "of Hereford" was as prolific and voluminous as, but more various in his themes than, Sylvester. He was born about 1563 in that Wye-watered city from which he took his designation, and educated in its old and excellent grammar-school. He was early distinguished for skill in penmanship, and soon won for himself a position in the highest society as an instructor. The noble families of Sidney, Pembroke, Derby, Egerton, &c., having been pupils, were his patrons. He was popular as a teacher in Oxford, and held the office of "master of penmanship to Prince Henry," son of James I. Fuller describes him as "the greatest master of the pen that England in her age beheld." Davies first married Mary, daughter of Thomas Croft, Esq., of Oakley Park, Salop; but she died 1st January, 1612; he next married 19th July, 1613, Dame Julian Preston, but she died prior to 25th May, 1614, and when he died he left a widow named Margaret. He complains sadly of irregularity of income and of being "oppressed with cares"—

> "Obscured by Fate, yet made a mark by Fame;
> Whereat fooles often shoot their bolts in game,
>
> . . . .
>
> I must ply my penne, which is my plough,
> Sith my life's sunne is almost in the west;
> And I'm provided yet but for unrest."

On 29th June, he "being sick of body, but of good and perfect mind and memory," made his will, and in the parish register of St. Dunstan's in the West, we read, "1618, July 6, bur[ied] John Davies of Hereford."

Though "weary fecundity and miscellaneousness" are characteristic of much of Davies' verse, there are many praiseworthy passages of rare and real poetic faculty in the plentifulness of his rhymes. Allegorical power and quaintness, serious thought and jocose mirth, bold personification and curious abstruse philosophizings are found in his pages. Here is a Falstaffian portrait of Polyphagus (Gluttony), one

> "Who was some two elles compasse in the waiste,
> And had not seen his knees since two days old.
>
> . . . .
>
> And over alle he wore a slabbered gowne,
> Which cloaked his buttocks, hugely overgrowne."

Epithymus the wanton is delicately attired:—

> "His doublet was carnation, cut with greene,
> Rich taffetas, quite through with ample cuttes,
> That so his waistcoat might eachwhere be seene.
>
> . . . .
>
> His hose was French, and did his doublet suit,
> For stuff and colour, to which sewed there were
> Silke stockings which sate strait his thighs about,
> To make his leg and thigh more quaint appear.
>
> . . . .
>
> His shoes were like to sandals, . . .
> . . . through the same the stockings did appear;
> And in the lachets were such ribbands put,
> As shadowed all the foote from sunne well neere.
>
> . . . .
>
> And to make up aright this woman-man,
> He at his face still fenced with a fan."

Malvolio surely sat for this portrait of self-conceit:—

> "His hat was bever, of a middle-size,
> The band silke-cypres fourfold wreathed about,
> A shallow cambric ruffe with settes precise,
> Closed with a buttoned string, which still hung out,
> Wherewith he played while he did plots devise,
> To gull the multitute and rule the rout,
> His suit was satin, pinched, and laced thicke
> As fit as faire, . . .
> His cloak cloth-rash with velvet throughly lined.
>
> . . . .
>
> His rapier hilts were black, which brightly shined.
> A velvet scabbard did that weapon warde,
> The hangers and the girdle richly wrought
> With silke of purest colour deerely bought.
> His stockings (suitable unto the same)
> Were of blacke silke and crosswise gartered,
> The knot whereof a rose's form did frame.
>
> . . . .
>
> His shoes were velvet (which his foot became):
> Thus was he clad from foote unto the head,
> Who still was still as one of judgment stayed,
> Before he hearde and poised what others said."

These pictures are vivid and real, so deft is the word-painting. Of a rich coward Davies says, "He is a leaden rapier in a golden sheath;" of deceit, "The forehead's falsehood is more seen than known;" and of dress,

> "The habit showeth how the heart is bent,
> For still the heart the habit doth prescribe."

"Mirum in Modum, a Glimpse of God's Glorie and the Soules Shape," appeared in 1602; to this, in 1607, he made an addition entitled "Summa Totalis: All in all and the same for Ever;" "Microcosmus" (1603); "Humour's Heaven and Earth;" and the "Holy Rood, or Christ's Crosse" (1609); "Wit's Pilgrimage" is undated; "A Select Second Husband for Sir Thomas Overbury's Wife, now a Matchless Widow" (1606); "The Scourge of Folly," and "Paper's Complaint" (1611); "The Muse's Sacrifice" (1612), and a great many other verses of varied character, showing wide range of thinking and sympathy, extensive knowledge, and felicitously expressed religious feelings.

Sir John Davies was the third son of John Davies of Chisgrove in Tisbury, Wiltshire. He was baptized 16th April, 1569, and probably educated in the Grammar School of Salisbury, which had been founded in the year of his birth by Queen Elizabeth. His father died in 1580, and under his mother's care he was sent to Winchester, whence, in 1585, he went as a commoner to Queen's College, Oxford. On 3rd February, 1587, he was entered as a student of the Middle Temple, London. Thus, when the city was all aglow with the poetical excitement of Spenser, Shakespeare, and Marlowe; the controversies of Nash and Harvey, Gosson and Lodge; the obsequies of Sidney, the stir of the Armada, the death of Leicester, the advancement of Essex, the early career of Bacon, and the expeditions of Gilbert, Raleigh, and Drake—he was brought into the full current of the ways of men. His mother died 20th March, 1590, in which year he graduated B.A. He dashed in among the poets, wits, and foplings of the time. His epigrammatic squiblets were many, and he claims ability to hold his own among the frivolous roisterers,

> "For vault and dance and fence and rhyme can I."

In 1593 "that suddaine, rash, half-capreol" of wit, "Orchestra, a poem on Dauncing," was "licensed to John Harrison"—though no earlier edition than 1596 is known. It was written in fifteen days, is vivacious in style and choice in diction. Love makes all things meet in a well-ordered dance.

> "What are breath, speech, echoes, music, wind,
> But dancings of the air in sundry kind?"

Stars, seas, streams, birds, all the best things in nature dance, and men have wrought into their imitative dancings

> "The motions seven that are in nature found,
> Upward and downward, forth and back again,
> To this side and to that, and turning round."

Even logic leadeth reason in a dance, all the seven liberal arts are simply graceful movements of thought, and dancing

is no mere new-fangled "frenzy and rage" just introduced into England's "great fortunate triangled isle."

> "Lo! this is Dancing's true nobility—
> Dancing, the child of Music and of Love;
> Dancing itself's both Love and Harmony,
> Where all agree, and all in order move;
> Dancing, the art that all arts does approve,
> The fair character of the world's consent,
> The Heaven's true figure and th'earth's ornament."

With equal adroitness, airy grace, sprightly buoyancy, and imaginative felicity he carries on the theme through 136 stanzas, and yet with a feeling of incompetency cries—

> "Oh that I had Homer's abundant veine,
> I would hereof another 'Ilias' make;
> Or else the Man of Mantua's charmed braine, [Virgil
> In whose great throate great Jove the thund'rer spake.
> Oh that I could old Geoffrey's Muse awake, [Chaucer
> Or borrow Colin's faire heroicke style, [Spenser
> Or smooth my rhymes withe Delia's Servant's file. [Daniel.

It was at the urgent pressure of a fellow-townsman, Richard Martin, that this poem blushed into being and rushed into print; yet in February, 1597–98, in a (probably political) squabble Davies assaulted Martin at the society's mess table, was expelled from the Temple, forfeited his rights as a member of the bar (to which he had been called in 1595). He occupied the early part of this rustication in the composition of "Hymnes to Astræa," published 1599, containing twenty-six acrostics on *Elizabeth* or *Regina*, and intended to propitiate the royal favour. This seemed too fulsome in its personality, and under better advice, towards the close of the same year, Davies produced "Nosce Teipsum" [Know Thyself] —probably the most marvellous metaphysics in metre ever written. It is in two parts—(1) of human knowledge, (2) of the soul of man and the immortality thereof. In this cobweb of his invention, "in outward form so light and trifling," he entered a "path in which he had no predecessor," and can hardly be said to have had a successor. It is in ten-syllabled lines, arranged in quatrains, each of which generally contains the condensed expression of a separate thought; and the great art of the poet is shown in compacting his varying ideas into the narrow limits of such unvarying measures. In it a quick, comprehensive intellect is combined with a noble and sagacious spirit, singular grace of fancy, preciseness of argumentation, and felicity of language to produce a poetic *Phædon* in which Platonism and Christianity are finely blended into a fresh philosophical form. It is dedicated to Elizabeth, "Loadstone to hearts and Loadstone to all eyes," as showing

> "Some sparkles of that fire
> Whereby we reason, move, and live, and be;
> Those sparks by Nature evermore aspire
> Which makes them to so high an Highness flee."

He had found that "sweet are the uses of adversity"—

> "This mistress lately plucked me by the eare
> And many a golden lesson hath me taught,
> Hath made my senses quick and reason cleare,
> Reformed my will and rectified my thought."

Davies was recalled to the bar in 1601, entered Parliament for Corfe Castle, Dorset, engaged in the suppression of monopolies, and visited James VI. in Scotland—to whom he presented a copy of his recent poem. On James's accession to the English throne the poet-lawyer was made, first, solicitor-general, and then attorney-general of Ireland. In 1606 he was gowned as serjeant-at-law, and in 1607 knighted. In 1612 he issued "A Discoverie of the True Causes why Ireland was never brought under Obedience to England," and in 1613 "Reports of Cases in the Law Courts of Ireland," the preface to which "vies with Coke in solidity of learning and equals Blackstone in classical illustrations and elegant language." In the first Irish Parliament under English rule (1613) he was Speaker of the Commons, and in 1615 he was made an English judge of assize. In November, 1626, Charles I. nominated him Lord Chief-justice of England, but before his installation he died of apoplexy, 7th December, 1626, and was buried in St. Martin's-in-the-Fields. He was exceedingly unfortunate in his domestic relations. His wife died in Bethlehem Hospital in 1652. His eldest son was born an idiot, and his beautiful daughter Lucy (Luci-da Vis) also suffered from an unsound mind. He must have written feelingly

> "I knowe my life a paine and but a spanne,
> I knowe my sense is mockt with everything,
> And to conclude, I knowe myselfe a man,
> Which is a proude and yet a wretched thinge."

John Donne—born in London in 1573—studied both at Oxford and Cambridge, and entered Lincoln's Inn. He was brought up a Roman Catholic, but having studied the subject, became, by conviction, a Protestant. He served as secretary to Lord Elsinore, fell in love with that nobleman's niece, and privately married her. He was imprisoned by his father-in-law, who took his wife from him; but by expensive legal process he recovered her, and was ultimately allowed as her portion £800, to be paid in equal instalments of £200. After long hesitation, and mainly at the instigation of King James I., for whom he wrote the "Pseudo-Martyr," Donne entered the church, and was made chaplain-in-ordinary to the king. Walton describes him as preaching as an angel *from* a cloud, not *in* a cloud. Cambridge made him D.D., Lincoln's Inn conferred on him its lectureship, and in his fifty-fourth year he was made Dean of St. Paul's and Vicar of St. Dunstan's. Being consumptive he was unable to preach. Some enemies asserted that he was too idle. He, though in a dying state, went to the pulpit, and, as it were, preached his own "funeral sermon"—published afterwards with the title of "Death's Duel." He died 31st March, 1631, and was buried under a shrouded effigy in St. Paul's Cathedral. His early poems are full of Roman Catholic sentiments and conceit; those composed in the interval between his unsettlement in faith and his decision are worldly, fleshly, and even prurient, flashes from the evil passions of a heart let loose and wildnesses of wit, realistic indeed, but

> "As filthie and more
> As a worm sucking an envenomed sore."

He was greatly admired in his own day for his exuberant wit, his sunny humour, his iridescent fancy, and the deep and subtle cadence of his verse. The fulness of his faculty, the curious felicity of his conceits, the characteristic nicety of his cunning touch, remained with him in that pure aftertime when the ash-gray sky had been removed from the lily-leaved life: his "Muse's white sinceritie" was given to the "all-changing, unchanged Ancient of Days." Of his divine poems the essence is—

> "As, perchance, carvers do not faces make,
> But that away which hid them there do take,
> Let crosses so take what hid Christ in thee,
> And be his image or not his, but He."

In his passage towards this period Donne was a pungent satirist, indeed the earliest of those who realistically revealed and rebuked the evil of those times. It is quite true that Joseph Hall, D.D., bishop, first of Exeter, then of Norwich, in his prologue (1597) to "Vergidemiarum" [*i.e.* of a harvest of rods] asserts—

> "I *first* adventure with fool-hardie might
> To tread the steps of perilous despight;
> I first adventure, follow me who list,
> And be the *second* English satirist."

But this is a boast depending for its truth on the scholastic definition of satire, *i.e.* as poems full of miscellaneous matter, containing discursive critical observations on real or imaginary characters, and moral reflections arising from these. In the more genial ideal of an attack on the vices, follies, crimes, and sins of an age, tinged with ironical humour, touched with telling allusions, and mixed with moral indignation, he had undoubted forerunners. Edward Hake, of Windsor, in "Newes out of St. Paules" (1579), says—

> "He sets to view the vices of the time,
> In novel verse and satire's sharpe effect,
> Still drawne along and penned in playnest rhyme,
> For sole intent good living to erect,
> And sin rescinde which rifely reignes abroad,
> In people's hearts full fraught with evil loade."

After him, "Mastyr George Gascoigne, a wittie gentyleman," who, in the "Steele Glass" (1576), as Whetstone says—

"Wrought a glass wherein eache man may see
Within his mind what cankered vices be."

Thomas Lodge's mordant "Fig for Momus," included in "Satyres, Eclogues, and Epistles," came out in 1595. But Hall states in 1599 that his rhymes were

"Begot long since of truth and holy rage,"

and that, though they were published and republished, he really meant them only to appear

"When I am dead and rotten in the dust."

Sir John Beaumont, elder brother of Francis Beaumont the dramatist, born at Grace-Dieu, Leicester, 1582, made verses the amusement of his youthful days. His most elaborate work, "The Crowne of Thornes," a poem in eight books, though (apparently) printed privately, is now lost. He published "The Metamorphoses of Tobacco" in 1602, a smoothly-versed eulogy of "the weed" which James I. detested and Sylvester loathed. This he celebrates as

"The marrow of the world, Starre of the West,
The pearle whereby this lower orb is blessed,
The joy of mortals, umpire of all strife,
Delight of nature, Mithridate of life [preservative],
The daintiest dish of a delicious feast," &c.

In the Registers of Westminster we find this record:—"1627, Sir John Beaumont, b[urie]d in the broad aisle on the south side. April 29." His son John, who also wrote verses, issued "Bosworth-Field," with "a taste of the variety of other poems left by his father," and dedicated them to "the king's most excellent majesty," 1629, as orphan verses. They were praised deservedly by Jonson, Drayton, Nevil, master of Trinity, &c. The lines describing the tyrant's death, "when trampled down and hewed with many swords," are forcible:—

"'Now strength no longer fortune can withstand,
I perish in the centre of my land!'
His handes he then with wreathes of grass enfolds,
And bites the earth which he so strictly holdes,
As if he would have borne it with him hence,
As lothe he was to lose his right's pretence."

Christopher Brooke, son of Robert Brooke, alderman and mayor of York, a member of the Inns of Court, who died and was buried in St. Andrew's, Holborn, 7th February, 1627–28, may be mentioned here for his "Ghost of Richard III." (1614). This poem is modelled on the historical legends of "The Mirror for Magistrates," and in well-polished lines presents a bold and vivid portraiture of the royal usurper. Brooke makes the tyrant, whose "greatnesse would be greater than itself," refer to Shakespeare as

"Him that imped my fame with Clio's quill,
Whose magic raised me from oblivion's den,
That writ my story on the Muses' hill,
And with my actions dignified his pen;
He that from Helicon sends many a rill,
Whose nectared veins are drunke by thirsty men:—
Crowned be his style with fame, his head with bays,
And none detract, but gratulate his praise."

Richard Niccols, born in 1584, entered Magdalen College, Oxford, 1602, and graduated B.A. 1606, in 1607 published "The Cuckoo," a vividly descriptive poem in couplets, under the inspiration and imitation of Spenser, and in 1610 edited and extended "The Mirror for Magistrates," giving as a "Winter Night's Vision" the following supplementary poems, viz.:—"King Arthur," "Edmund Ironside," "Prince Alfred," "Godwin, Earl of Kent," "Robert (Curthose)," "Richard I.," "King John," "Edward II.," "The Two Young Princes murdered in the Tower," "Richard III.," feeling, as he says, so inspired that he

"In statelie style, tragedian-like, with sacred furie fed,
Must now record the tragicke deeds of great heroes dead."

In "John" and "Richard III." the influence of Shakespeare is distinctly perceptible. His "Beggar's Ape," a severe satire on King James's readiness to confer knighthoods, &c., was withdrawn from circulation.

Perhaps we might also note here "The Rewarde of Wickednesse," by Richard Robinson, servant of the Earl of Shrewsbury, who composed his book upon the pattern of "The Mirror for Magistrates," while acting as sentinel guarding, during the night-watches, Mary Queen of Scots, in Sheffield Castle, 1574. Just after having spent the evening with a set of jolly comrades in an alehouse, he falls asleep and dreams that Morpheus leads him to the infernal regions, and there he sees in different compartments many sinful persons, who tell the author their histories and their miseries. Among these are Helen (of Troy), Pope Alexander VI., Tarquin, Medea, Tantalus, Heliogabalus, Midas, &c.

Great as was the repute of "The Mirror for Magistrates," it was regarded as outshone by a poem in which Michael Drayton says there were passages

"So fine, so clear and new,
As yet they have been equalled but by few."

This was "Albion's England," by William Warner, who "first breathed the air in London" in Elizabeth's first year (1558), student of Magdalen College, Oxford, who was retained in the service of Henry Carey, Lord Hunsdon, and was a man of good years, honest reputation, an attorney of the Common Pleas, when he died at Amwell, Hertfordshire, suddenly, 9th March, 1608-9. Simplicity, ease, pathos, moral tone, and careful observation of the operation of emotion mark the verses in which, after the manner of the best old ballads, he endeavoured to recount the incidents of British history. It was printed in 1586, but being unauthorized was not published till 1589; afterwards it was enlarged in several successive editions, till it contained sixteen books, and was brought up to Elizabeth's time. The author, thinking her era "penwork for a king," called upon James with his own rhyme-royal to continue his work. Warner was also author of "Pan-his-Syrinx, or a Sevenfold Historie" (1584 and 1597). Among other chronicles in verse might be named Richard Jackson's "Battle of Flodden," a famous old ballad (1564); Ulpian Fulwell's "Flower of Fame" (1575), celebrating "the bright renowne and most fortunate reign of Henry VIII.," author also of the coarse but clever "Ars Adulandi" (the Art of Flattery), and "Like will to Like, saith the Devil to the Collier," a roughly humorous comedy; William Storer's remarkable "Life and Death of Thomas Wolsey, Cardinal" (1599); Thomas Wenman's "Legend of Mary Queen of Scots" (1601); William Harbert's Welsh-tinged, but quick and aphoristic, "Prophesie of Cadwallader, last King of the Britaines" (1604), who gives a running series of parallels between English sovereigns and eminent Romans. Nor may we omit, despite the lugubriousness of the name and much of the work of one who trailed a pike in Henry VIII's. time, was a pensioner of Queen Elizabeth, saw James I. seated on the throne, wrote seventy volumes in prose and verse, whom Spenser noticed in his "Colin Clout" as "old Palamon free from spight,"

"That sang so long, until quite hoarse he grew."

Thomas Churchyard (1520–1604), was "one of those unfortunate men," Isaac D'Israeli says, "who have written poetry all their days, and lived a long life to complete the misfortune." Thomas Nash kindly said of his best production: "Shore's wife is young yet, though you be steeped in years; in her shall you live when you are dead." His "Worthiness of Wales," describing Welsh places and people, is his most popular work.

Another name belonging to a race of poets rises into memory, that of Giles Fletcher, LL.D. (father of Giles and Phinehas, and uncle of John Fletcher), born at Watford, 1548, educated at Eton and King's College, Cambridge, where he graduated B.A. 1569, M.A. 1573, married 1580 at Cranbrook, where his father was vicar, Joan Sheafe, and took LL.D. 1581. He entered Parliament for Winchelsea, 1585, and went as Commissioner to Scotland, 1586, Holland, Germany, and Russia, as secretary to the ambassador in 1588, in regard to which he wrote "The Russe Commonwealth." He was appointed remembrancer of the city of

London, and somewhat later treasurer of St. Paul's, but was reduced to great straits by the sudden death of his brother Richard, for whom he had undertaken some suretyship. On 11th March he died in London. He had projected and proposed to Burleigh "A History of the Reign of Elizabeth." He is the author of many occasional Latin poems, of "Licia, or Poems of Love in honour of the admirable and singular virtues of his Lady," whereunto is added "The Rising to the Crown of Richard III." (1593). "Licia" is all athrob with emotion, subtlety of idea, and poetical power. Listen—

"Wearie was love, and sought to take his rest,
He made his choice uppon a virgin's lap:
And slylie crept from thence unto her breast,
Where still he meant to sport him in his happe.
The virgin frownede, like Phœbus in a cloude,
'Go back, sir boye, here is no roome for such;
My breast no wanton foolish toyes must shroude.'
This saide, my love did give the wagge a touch;
Then as the foote that treads the stinging snake
Hastes to be gone, for fear what may ensue,
So love, my love, was forced for to forsake,
And for more speede without his arrowes flew.
'Pardon,' he saide, 'for why, you seemed to me
My mother, Venus, in her pride to be.'"

Giles Fletcher's poem on Richard III., besides its own interest as an addition to the narrative soliloquies in the style of the "Mirror for Magistrates," helps to determine the date of Shakespeare's play as 1593–94.

Any adequate treatment of the productions of the poets of Elizabeth's time is quite impossible in the few pages into which all that we may say must be compressed. Of those whose published works are known there are 250, and even to name these and their works in the merest running catalogue would exhaust our space. Peter Beverley may, by his (1565) version of "Ariodante and Ginevra," from Ariosto, have furnished Shakespeare with the groundwork of "Much Ado about Nothing." Stephen Batman, chaplain and librarian to Archbishop Parker, may not have attracted the dramatist much by his allegorico-theological poem on man's life, "The Travelled Pilgrime" (1569), though his golden "Booke of the Leaden Gods" (1577) almost certainly contributed to his knowledge of the Pantheon, and of his reading of Batman on Bartholomew Glanville's book "De Proprietatibus Rerum" (1582) traces have been found. To Lodowick Bryskett we owe not only "The Mourning Muse of Thestylis," which Spenser added to his Astrophell, as written by a swain

"Of gentle wit and daintie sweet device,"

but also the effective stimulation which he applied to his friend to continue his labour on the "Faerie Queene," so nicely acknowledged in "Amoretti" (33). Thomas Freeman enjoyed the reputation of a clever epigrammatist, and the friendship of Donne, Daniel, Chapman, Spenser, Shakespeare, &c., to whom he addressed verses in "Rubbe and a Great Cast" (1614). Anthony Chute, under the title of "Beauties Dishonoured," writes of Shore's wife, and is reputed by Nash as author of "Procris and Cephalus" (1593), which may be the poem alluded to in "Midsummer Night's Dream," as Dunstan Gales' "Pyramus and Thisbe" (1596), which Greene called "a lovely poem," may have been that on which the "tedious brief scene" presented by Bottom, Quince, & Co. was founded. Stephen Gosson, though opposed to plays (of which he wrote a few), was "for his admirable penning of pastorals," as Antony Wood says, ranked with Sir Philip Sidney, Thomas Chaloner, Edmund Spenser, Abraham Fraunce, and Richard Barnefield. Richard Hunnis, master of the children of her Majesty's chapel, punningly presented "A Hive full of Hunneye" (1578), the Book of Genesis in verse, "A Handful of Honnisuckles," and gave vent to the "Seven Sobs of a Sorrowful Soule for Sinne" in 1585, entirely in jingling monosyllables, thus:—

"Thy love, O Christ, is farre more deare, and farre more sweet to me,
Than wealth, or wine, or limbe, or life, or aught that I can see."

To such verses as this he reduced the first book of Moses—

"Then Joseph, lifting up his eyes, young Benjamin espied,
Said he, is this young Benjamin of whom you spake before?
My sonne, to thee God mercy show, said he, for evermore!
And Joseph hasted him away, his teares began to fall;
His heart upon young Benjamin did yearn and melt withal.
So he into his chamber went, that none might him espie,
And there a space did weep and shed forth tears abundantly."

Several others set forth in verse the books of Scripture. Judson Smith (1575), Dudley Fenner (1587,) Gervase Markham (1595), and Rev. John Loe (1620) put the Song of Solomon into metre. Both Thomas Middleton and Henry Lok, gentleman (1597), versified Ecclesiastes. Of the style of the latter, who was a facile sonneteer, and had a specimen of his work prefixed to James I.'s "Poetical Exercises" (1591), only this needs be given:—

"A good name sweeter is than oyle, death's day than day of birth;
In mourning-house more good is learned than in the house of mirth."

Christopher Fetherstone, author of a "Dialogue against Dancing" (1582), gave in 1587 "The Lamentations of Jeremiah, with apt notes to sing them withal." By Robert Holland "The Holie Historie of Our Lord and Saviour" was, in 1594, "gathered into English meeter and published to withdrawe vaine wits from all unsavourie and wicked rhymes and fables to some love and liking of spiritual songs and holie Scripture." John Marbeck, with the same aim, had issued in 1579 "The Holie Historie of King David;" and Henoch Clapham—minister of the Scotch Church in Amsterdam, and a voluminous theological controversialist—followed in 1596 with "A Briefe of the Bible History, drawne first into English Poesy."

Henry Constable, a great master of the English tongue, and of pure, quick, and conceitful mind, born about 1560, was author of "Diana," a collection of fine spiritual sonnettes to the honour of God and his saints; and a large number of miscellaneous poems, many of most airy grace and dainty expression, including "foure Sonnets to Sir Philip Sidney's Soule," and "The Shepherd's Song of Venus and Adonis." He was a Roman Catholic who suffered imprisonment in the Tower for his faith, and died 1612. Here is a verse of Damelus' song to his Diaphania, which charmingly "dallies with the innocence of love."

"Diaphania, like the daffadowndilly,
White as the sun, faire as the lily,
Heigho! how I do love thee;
I do love thee as my lambs
Are beloved of their dams,
How blest were I if thou would'st prove me."

Sir Thomas Overbury's most exquisite and singular poem of the "Choice of a Wife," though it abounds in good sense and elegant expression, owes a good deal of its popularity to the tragic fate of its author. He was born at Barton-on-the-Heath, Warwickshire, 1581, became intimate with Carr (Earl of Somerset), and was knighted through his influence. Carr procured the divorce of the Earl of Essex from his wife and married the lady. Overbury disapproved, threatened to reveal some political secrets, and by Carr's intrigues he was sent to the Tower, where he was insidiously poisoned, and died 15th September, 1613. Two years afterwards the guilt of Carr and his wife was disclosed. His poem "A Wife" (1614) led to the issue of "The Husband" in 1616 (anonymous); John Davies' "Select Second Husband for Sir T. Overbury's Wife;" Richard Braithwaite's "Description of a Good Wife;" and Patrick Hannay's "A Happy Husband" (1619). Davies characterizes Overbury's poem as "the wittiest wife that ere was made for wisest husband's use," and calls him "the wittiest innocent that ever died to live, for live he must." His prose "Characters" have had wider popularity than his poems.

William Barksted—an actor who in 1606 performed in Jonson's "Epicene," and in Beaumont and Fletcher's "Coxcomb" in 1613—perhaps requires mention, because in his "Mirrha, the Mother of Adonis, or Lust's Prodigies"

(1607), he affiliates his song to the first heir of Shakespeare's "invention," and thus expresses himself regarding it:—

> "But stay, my Muse, in thine owne confines keep
> And wage not warre with so deare loved a neighbour,
> But having sung thy day-song, rest and sleepe,
> Preserve thy small fame and his greater favour;
> His song was worthie merit (Shakespeare hee)
> Sung the fair blossome, thou the withered tree,
> Laurell is due to him—his arte and wit
> Hath purchased it, cypress thy browe will fit."

His "Hiren, or the faire Greeke" (1611) is dedicated to Henry, earl of Oxford, as "the bashful utterance of a maiden muse," and is perhaps referred to in Shakespeare's "Have we not Hiren here?" (2 Henry IV. ii. iv. 173, 189). He really does say some fine things, as—

> "Night, like a masque, has entered Heaven's greate hall,
> With thousand torches ushering the way."

> "The red-cheeked Morning opens now her gate,
> The busie Day breathes life into the world."

"Skialetheia, or a Shadow of Truth" (1598), by Edward Guilpin—of whom nothing is known but that he was a Cambridge man, a friend of Markham's, and probably of Daniel, Drayton, Spenser, &c., whom he praises—is a tart satirist, and has been frequently quoted in that treasury of poetic sweets, "England's Parnassus" (1600), *e.g.*—

> "Opinion is as various as slight change . . .
> She's any humour's perfect parasite . . . .
> She is the echo of inconstansie."

In consideration of the way in which Richard Barnefield's name has been connected with Shakespeare's, we mention the author of "Cynthia" and a very fine "Legend of Cassandra" (1595). He was born in Norbury, Shropshire, 1574; educated at Brazenose College, Oxford, studied at Gray's Inn; issued "The Affectionate Shepheard" (anonymously) 1594, and acknowledged it in "Cynthia." It is dedicated to Ladie Penelope Rich (Sidney's Stella) as "This new-born babe, which here my Muse brings forth." In 1598 his "Encomium of Lady Pecunia" came out. He seems thereafter to have retired to his estate of Dorlestone, Staffordshire. He, however, retained his literary tastes, and in 1605 issued a new and altered edition of "Lady Pecunia," in which, with reference to Jaggard's having included the sonnet "If Musique and Sweete Poetrie agree," and the verses "As it fell upon a Day" in "The Passionate Pilgrime" (1599) as by W. Shakespeare, he says—

> "I writt these lines, fruites of unriper yeares."

Among poets he specially praises Spenser, Daniel, Drayton, and Shakespeare, of the latter of whom he says,

> "And Shakespeare, thou whose honie-flowing veine,
> (Pleasing the world) thy praises doth obtaine,
> Whose *Venus* and whose *Lucrece* (sweete and chaste)
> Thy name in Fame's immortal book have plac't;
> Live ever you—at least, in Fame, live ever;
> Well may the body die, but Fame dies never."

He died, and was buried in the church of St. Michael's, in Stone, 1626.

William Basse is another minor poet who, mainly as the author of the "Epitaph on Shakespeare" signed W. B., published in 1633, but known to Jonson in 1623, has hitherto received notice. He is, however, author of "Clio," in nine eclogues on nine virtues; "Urania, the Woman in the Moone;" "The Metamorphosis of the Walnutt-tree of Borestal;" "Great Bretane's Sun-sette," a shower of teares on the death of Prince Henry; and before his death he collected his scattered verses under the title "Polyhymnia," in 1653, but these have only recently been printed. Eve having been taken up to heaven creates such excitement that the gods refuse to live there exposed to woman's competition, and say to Jupiter:—

> "If thou wilt needs do her base world that grace
> As to detain her here, then send us thither;
> For thou shalt find that state in cursed case
> Where Fates and women domineer together;
> Where we are, Jove, there needs no such as she,
> Where she is needs no other destinie."

HISTORY.—CHAPTER XII.

MAHOMET AND MOHAMMEDANISM — THE SHAPING OF THE NATIONS AND THE PROGRESS OF SOCIETY—THE DEVELOPMENT OF THE CHURCH.

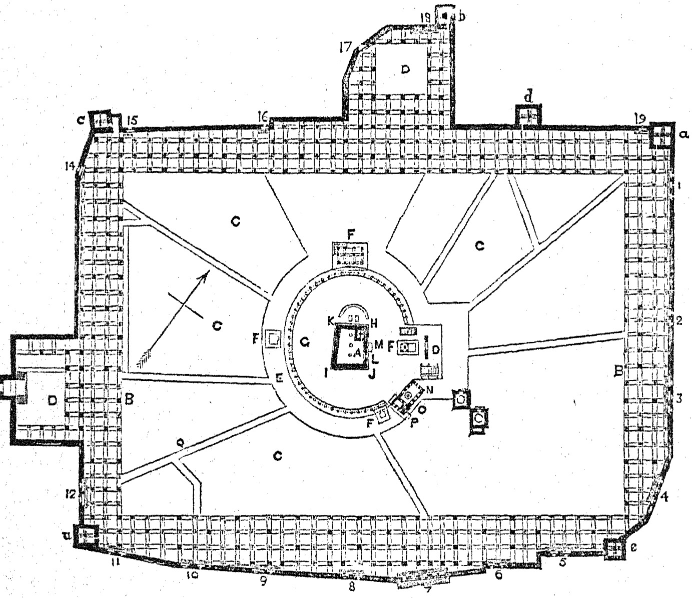
Section I. Mahomet and Mohammedanism.

TRAJAN had, in 107, carried the Roman arms into the interior of Arabia. Some of its northern tribes were brought to submission, but it was not subordinated to the empire. When, therefore, the decline of the Roman power began, strife and lawlessness manifested themselves in this "anti-industrial central point in the world." The Arab races remained in a scattered, nomadic, disorganized condition, and several centuries of tribal warfare and clan contentions—the theme of many an Eastern poet's ballad-songs—kept the land in turmoil, although after the destruction of Jerusalem many Jews had passed into Arabia, carrying with them a knowledge of scripture truths and Christian faith. Arabia is really little more than a name in early books, and in these times its people wrote nothing worthy of note on the page of history. The Greeks named its inhabitants, from their own term *Sharkeyn* (*i.e.* Eastern people), *Sarkenoi*, and the Romans transformed this into *Saraceni;* hence our word Saracen, used by mediæval writers to designate the Arabs generally, but especially those who invaded Europe and introduced a creed opposed to the true faith of the Catholic Church.

For in the latter half of the sixth century, far away from the wonderful revolutions of the West, an event occurred which dwarfs, in comparison to its unexpected importance, the wise administration of Theodoric and the consolidation of the conquests of Clovis. A Koreish family in Mecca, which had long held the office of Keepers of the Caaba—that strange stone which was said to cover the grave of Abraham—had born into it, in 569, a child who, when his father died early, was brought up under the care of an uncle. He was trained to warlike exercises and commercial subtleties. Sword and horse were alike under his control, and the caravan had no more accomplished cavalier in its march through the deserts. He was of poetic temper and inquiring intellect. He saw visions, dreamed dreams, and sighed for their realization. His twice-widowed mistress Caijah, perceiving the aspiring nature of the poor, unknown, solitary, and much younger *Halabi*, offered him the place of a husband. He elatedly chose his fate, and was wedded. It was not till he had attained his fortieth year that "the seal of prophecy" was laid upon him, and he became aware of having a mission. He was then tall, broad shouldered, stoutly built, though rather lean, with a large shapely head, round which dark hair hung in graceful curls, great coal-black eyes under bushy eyebrows, a goodly-sized well-formed nose, and a long beard. In the solitude of Mount Hira, near Mecca, the angel Gabriel appeared to him and called him to preach the true religion, to commit it to writing, and spread it over the whole earth. God had already fulfilled the saying of his ancient prophet Haggai (ii. 7), "I will shake the nations." He had now to fulfil the remainder of that promise, "the Desire of all nations shall come," and Halabi was this *Mohammed* (*i.e.* the predicted Messiah) who was to teach *Islam*—resignation to the will and law of God, both as *Iman* (*i.e.* a theory or faith) and *Din* (*i.e.* a practice). This is taught in the Koran (Arab., *Karaa*, to read), that is, The Reading, which is also known as *Al-Kitab*, the Book; *Al-Moshaf*, the Volume; and *Forkan*, Salvation. This revelation was written from all eternity with rays of uncreated light on a tablet beside the everlasting throne of God. A copy of it, bound in milk-white silk, adorned with gold and jewels, was brought down to the lowest heaven by Gabriel on the blessed night of Al-Khadr, in the month of Ramadan, and during twenty-three years its contents were gradually communicated to Mahomet and translated by inspiration into human speech. Its style is said to be most elegant and pure, and is now considered as classical. It seems to be a blended essence of Judaism, Christianity, and Heathenism—intended to become acceptable to all, because including the main points of each. His doctrines and assumptions were opposed with violence. He fled to Medina (622), and this is called the epoch of *Hegira* (Flight). With the Koran in one hand and a sabre in the other he laid the foundation of a vast disciple-

ship. In 632 he died, and before a century had elapsed his standard (*bajura*) was borne in triumph over Arabia, Syria, Persia, Egypt, and all the southern coast of the Mediterranean, whence it crossed over into Spain.

Mahomet was succeeded, after considerable contention, by his nephew Abu-Beker. Omar, who followed, burnt the celebrated library of Alexandria. The Emir was assassinated in 644. Othman succeeded to power, and took Rhodes and Cyprus. He was murdered in 654, and his successor Ali met with the same fate in 660. The dynasty of the Ommiades commenced with Othman's cousin Moawiyah, who



Plan of the Prophet's Mosque, Mecca.

a b c d e, Minarets; 1 to 19, Babs or gates; A, Caaba; BB, Cloisters; CC, Gravel; D, Bab-el-Salem; E, Outer step; FFFF, Makam Hanafy, north—Makam Maleky, west—Makam Kanbaty, south—Makam Ibraham, east; G, Oval circuit; H, Irak corner; I, Yemani corner; J, Black stone; K, Shami corner; L, Door; M, Maajan; N, El Daraj; O, Zemzem; P, Staircase; Q, Raised pavement.

compelled his nephew to abdicate in 661. He conquered Khorassan, invaded Turkestan, overran Sicily, and besieged Constantinople; but being defeated in Syria, Sicily was seized by the Lombards. He died in 679. Yezid, his son and successor, continued these attacks upon the empire, but neither under him nor Moawiyah II. (683) or Mervan I. were any great feats accomplished. After them Abdulmelek made himself master of Islam, and maintained his position. He was a patron of poetry and art. Four of his sons successively wielded the sceptre, while by a fifth (uncrowned) son, Mosslemeh, their sway was extended to the Indus, and while he rode through the principal streets of Constantinople Leo III. was compelled to walk on foot and pay £140,000 for the ransom of his capital, from the spire of which the crescent gleamed. On the death of this unmatched leader of the Ommiades insurrection and civil contention ensued. The dynasty of the Abbasides was begun in the person of the famous Abu-Mosslem, whose troops were defeated by Charles Martel at Tours in 732, and almost annihilated at Narbonne in 736. A few temporary sovereigns of the Ommiades took the throne, but Abu-Mosslem overmastered them, and amid the ruins of Meru (747), the power of the Abbasides was proclaimed in the East. The Ommiades passed over into Africa in 750, dashed across the Straits of Gibraltar and appeared among the effete kings, the divided people, the self-confident Church, with the creed and the crescent of Islam. Then under Abdurrahman I. they established themselves in Spain, 751. The ballads of the time tell of the achievements of the combined force of Arabs, Navarrese, and Gassans which he led against Charlemagne in 778:

> "When Roland brave and Olivier,
> And every paladin and peer
> On Roncesvalles died."

His successors were much troubled with internal revolts, and "the Spanish March" was established as a barrier against their further encroachments on Christendom. Though engaged in incessant wars against the Christians, Abdurrahman II. (821-832) made Mohammedan Spain the best governed country in Europe. His successors continued in his ways, and under Abdurrahman III. (912-960) the golden age of Islam rule in Spain was reached. Under the peasant Vizier, in the regency of Sobeiha, while Hessem II. (minor) was nominally Caliph, the Ommiades received a terrible defeat —from Castile, Leon, Barcelona, and Navarre, in 1001—at Calet Anasor. Disorder and civil war ensued, the power of the Ommiades waned, and they disappeared from history.

In the East, under Al-Mansor, born at Homaima in Syria (713), who succeeded his brother Al-Saffah (753), the Abbasides began the most glorious period of Arabian Empire. In 762 Bagdad was built. Al-Mansor died 776, and was succeeded by his son Al-Mohdi, whose son afterwards reigned; and then Al-Mansor's grandson, who had carried the crescent through the Greek provinces of Asia Minor to the Hellespont, was called to the throne. His reign—the era of the "Arabian Nights"—became the most famous in the history of the Caliphate. Flourishing towns sprang up, traffic by land and sea increased, wealth and comfort were multiplied. Bagdad rivalled Constantinople, and friendly communications were opened with the court of his celebrated contemporary Charlemagne.

> "In sooth it was a goodly time,
> For it was in the golden prime
> Of good Haroun Al-raschid."

Among the Mohammedans the secular sovereignty and the supreme priesthood were united in the Caliph, and hence unity of aim was secured; but revolts against this individual pre-eminence sometimes occurred and in an expedition against such a rising at Khorassan Haroun died, 808. His two sons strove for dominion, and Mamun prevailed. He founded colleges and libraries in the chief cities of the Caliphate, built observatories, and favoured the diffusion of knowledge. As almost always happens, luxury and love of pleasure lessened the enthusiasm of faith, and every here and there satraps threw off their allegiance and assumed monarchical powers. The empire was disordered, and notwithstanding numerous concessions nearly a century of turmoil set in. The Caliphate became almost nominal, and the authority of the government was all but entirely wielded by the Emir Al-Omara ("commander of commanders"), which ultimately became hereditary. These emirs soon exercised sovereignty in their principalities, and the Caliph rather became a supreme pontiff than a secular sovereign, so numerous were the independent states which recognized him only as *Iman*—a faith; and face to face, after a thousand years of Christian teaching, stood at last the Church and the Caliphate, the Crescent and the Cross, alike claimants of spiritual sovereignty, and aiming to be the umpires in all the dissensions of the masses and of monarchs. Something must be done. When it was known that the Saracens had destroyed the church of the Resurrection at Jerusalem, Pope Sylvester uttered the cry, "Soldiers of Christ, arise and fight for Zion!" Europe was awakened to the startling crisis, and the Crusades were imminent.

Section II.—The Shaping of the Nations and the Progress of Society.

Charlemagne had established a great empire, and this he handed down to his son Louis, *le Debonnaire*, king of France and emperor of the West; but the genius required to maintain the awe of power among discordant nationalities was wanting in the pious yet pusillanimous Carlovingian. He refunded the exactions and restored the unjust conquests of

his father. He stripped the bishops of their lay-lordship, and strove to reform the monastic orders. The church had little sympathy for his simple and generous virtue, and through his weakness found the means of increasing its power. Bernard, the illegitimate son of Pepin, Louis' elder brother, who had been made King of Italy by his grandfather, conspired to dethrone his uncle. Louis seized Bernard, and by advice of his council, ordered his eyes to be put out. He died, and Louis, smitten with remorse, did penance for this piece of state-craft, as if it had been a crime, before a bench of bishops. Finding both the outer circle of his enemies becoming combined and powerful, and the inner communities of his subjects more unruly and dissatisfied, Louis bethought himself of making a division of the empire among his children. He associated with himself in the imperial government Lothaire, the eldest; to Pepin he assigned Aquitania, and to Louis, Bavaria. These brothers quarrelled among themselves, and only agreed in their opposition to their father. The open war they at length commenced against him was connived at by Pope Gregory IV. Louis the Pious had married a second wife, Judith, and having a son, Charles "the Bald," born of her, desired to provide a kingdom for him. The sons denounced their stepmother as a bad, bold, ambitious woman, seized their father, and shut him up in a monastery. The brothers disagreed, the father escaped and secured submission. Only a short respite was given him from care. The revolt was renewed. Lothaire led his father, stripped of his military baldric and clad in a shirt of hair, through the streets of Aix-la-Chapelle, and he was again harshly confined in a monastery. Lothaire assumed the position of sole emperor. Fresh dissensions arose, the old emperor was restored, and Judith induced him to place her son Charles in the position of Pepin, whose death had left Aquitania kingless. To Lothaire Louis assigned all Italy, Provence, Lyons, Swabia, Austrasia, and Saxony; to Louis, Bavaria; and to Charles, Neustria (*i.e.* Eastern France) and Aquitania. Not content with Bavaria, Louis claimed the Rhine frontier and rebelled. His father marched against him. A diet was summoned at Worms to adjudicate on his claim, but the emperor fell ill on an island in the Rhine, near Mayence, sent the imperial crown, sceptre, and sword to Lothaire, and died in 840. Lothaire was acknowledged as emperor; Louis acquired the territory he sought, and the empire of Charlemagne was disparted into three. The testamentary settlement of Louis did not last long. Lothaire attempted to seize the whole imperial territory, was opposed and defeated by his brothers at Fontenoy (842), and the old arrangement was confirmed by treaty, Lothaire having all Italy and the lands lying between the Rhone, the Alps, the Meuse, and the Rhine; Louis all the provinces east of the Rhine, and the title King of Germany; Charles Neustria and Aquitania, with the title King of France. Of Italy Lothaire made his son and namesake king. The death of Lothaire I. in 855 caused a new dismemberment. Louis of Germany became emperor and took Italy. Charles reserved Provence and the territory between the Rhone, the Alps, and the Mediterranean, the kingdom assigned to Lothaire II. being the lands between the Scheldt, Rhine, Meuse, Saône, called Lotharingia or Lorraine. Louis invaded France and dethroned Charles the Bald, but *le Chauve* was afterwards reinstated by the influence of the clergy, who had, amidst these family contentions, greatly augmented the powers of the church, evaded the imperial confirmation of the election of popes, and claimed exemption from civil jurisdiction.

Lothaire II. died in 869, and his territories were divided between his brothers. Louis passed away without male heirs in 875, and Charles, who was a most submissive son of the church, accepted papal confirmation in the imperial dignity and the possession of Italy from Pope John VIII. Shortly thereafter, the death of Louis of Germany led to a tripartition of his kingdom among his sons. Carloman received Bavaria; Louis, Saxony; and Charles the Fat, Swabia. Charles the Bald, attempting to seize their kingdoms, was defeated at Andernach, and overtaken in a storm died (877) in a cottage at the foot of Mont Cenis. He was succeeded by Louis the Stammerer, his son, who did not assume the imperial title, and whose reign only extended over two years. His two sons, Louis III. and Carloman, succeeded, the one to Neustria and the other to Aquitania. Duke Boson, husband of Imogene their sister, had the kingdom of Arles—including Provence, Dauphiné, Lyons, Savoy, and Franche-Comté allotted to him, and was crowned King of Burgundy by the archbishop at Lyons. Louis dying 882, Carloman became sole king of France. Charles the Fat, on Carloman's death (884), became heir to all the territorial possessions of Charlemagne, except Arles and the Spanish borders. He ceded Friesland to the Normans; but afterwards, in a treacherous manner, murdered their king. This led the Norse to besiege Paris. Odo and the Bishop Gozlier performed prodigies of valour, baffling their 40,000 assailants, in high hope of help from Charles. He came, encamped at Montmartre, but leaving Odo unaided, he bought off the besiegers, who carried on their depredations elsewhere. The empire was indignant. Charles was deposed, and soon afterwards died, in 888. Odo was by acclamation proclaimed King of France; but at his death, in 898, Charles the Simple, the heir, was accepted as sovereign, and he in 911 ceded to Rollo a part of Neustria, afterwards known as Normandy. Arnulph, Carloman of Bavaria's illegitimate son, was chosen King of Germany and Lorraine. His reign was turbulent and agitated. He made several expeditions into Italy, and was, after being sharply dealt with, at last defeated by the Hungarians. On his death (899) Louis, his son, a minor, succeeded him, and died in 911. Then Charles the Simple became rightful heir; but the Germans despising him, chose Conrad of Franconia, then duke of Bavaria, as their king, and with him the special history of Germany as a nation begins. He was prudent and valiant; but the Lorrainers, discontented with his election, rejected his rule, and he was unable to enforce submission. The restlessness of the nobles and the incursions of the Hungarians greatly distressed his short reign. When Conrad lay dying of a wound got at Limburg, on the Lahn, in an expedition against the Huns, he called his brother Eberhard to his bedside, explained to him the toils and cares of state, recommended him to surrender any claim he might have, and agree with him in nominating Henry the Fowler, duke of Saxony and Thuringia. Conrad I. died December, 918, and in the beginning of 919 the Franks and the Saxons elected Henry for their sovereign, and with uplifted hands swore fealty to him as king.

Upper or Imperial Italy was left a prey to faction, wars ensued, and, first, Berengarius, duke of Friuli, was acknowledged king; then Guy, duke of Spoleto, defeating him, seized the throne and transmitted it to his son Lambert, who, till his death in 898, was king. Berengarius again assuming the sceptre, defeated his opponent, the son of Boson of Burgundy, and was lord of Italy. He did not, however, remain its undisputed master. The Arabs ravaged the south, the Huns the north, and the Church intrigued everywhere. Rudolph I. of Burgundy, beyond Jura, troubled him; but ultimately resigned his claim to Hugues, marquis of Provence, on receiving Cis-Juran Burgundy (*i.e.* Franche-Comté, Chalons, Macon, Vienne, Lyons, and parts of Languedoc and Provence), which he joined with Switzerland, Savoy, and trans-Juran Burgundy into the kingdom of Arles. Hugues entered the lists against Berengarius I., continued his opposition to Berengarius II., and succeeded in getting his son Lothaire seated on the throne of Italy. On his death Berengarius II. married Lothaire's widow Adelaide, and was accepted as king. She, being ill treated, sought the aid of Otho of Germany, and he, marching into Italy, made himself possessor of the sceptre and crown of Lombardy.

During the turmoils of change, 911 to 915, the reign of Charles the Simple was not a peaceful one. The Saxons had waged war with him because he had accepted the homage of the Lorrainers, and when Henry I. became King of Germany he was compelled to sign a treaty at Bonn, 923. Afterwards Charles' vassals rebelled, placed at their head Robert, son of Odo, and with the help of Germany offered battle at Soissons. Robert was slain in this engagement; but his son Hugues taking the command, was victorious, and Raoul, duc de Bourgogne, was elected king instead of Charles. He was cajoled into Vermandois and imprisoned, 923. He died 929. His wife, sister of Athelstan, sought refuge in England with her son Louis, who subsequently be-

came king under the name of Louis IV. *Outremer* (*i.e.* beyond sea). Neither he nor his son Lothaire could restore the crown to dignity or make the sovereignty powerful, and under Louis V.—unable to resist the incursions of the Normans and the Huns—the influence of the throne was further lessened. Hugh *Capet*, son of Hugues the Great, seized the dominion, had himself proclaimed at Noyau and crowned at Rheims, and when Charles of Lorraine, Louis' uncle and heir, advanced to assert his rights, Louis met captivity and death, and the dynasty of Charlemagne ended, in 987.

As a sovereign Hugh Capet held a merely titular position as King of the French. He was master of his own lands, and feudal superior of the crown vassals; but these, growing refractory, sometimes defied him and waged war against him, even in Paris and Orleans. He took the precaution of having his son Robert crowned during his lifetime, and in the next two reigns this example was followed. Robert did not trouble himself much to extend the regal power. Henry I. made an unsuccessful attempt to win Normandy during the minority of William, and Philip I., in the time of the Crusades, did all he could to enlarge the limits of the royalty. In the days of Louis the Fat those wars between England and France, which for more than three centuries kept both lands in a broil, began. But the French line of kings was fortunate in their each having sons capable of taking up the succession without break, and so, bit by bit, one way and another, the French kingdom was built up strongly and firmly as an independent nation.

After Charlemagne's time the eastern portion of the territories of the mighty mistress of the world dwindled into the Greek Empire. It was harassed by external enemies and internal dissensions. Leo the Armenian, son of Bardas, who under Nicephorus I. had risen to high position, but had been exiled, was recalled by Michael Rhangabe in 811. He excited the troops against his benefactor, who retired to a convent, and the ungrateful Leo entered Constantinople to be crowned in 813. He overcame the Bulgarians; but his despotism led to his being assassinated at the altar by conspirators robed as priests, in 820. Michael II. succeeded. During his reign the Saracens conquered the island of Crete (Candia), and seized Sicily and several parts of Italy. The government of his son and successor, Theophilus (829-42), was mild and fair. He left a son, Michael, six years of age, for whom his mother, Theodora, acted as regent. He proved dissolute and tyrannous, and after associating Basilius with him in the sovereignty was assassinated in 867. In the reign of Basilius as sole emperor many victories were attained over the Saracens, and the great schism, arising out of the anathematizing of Photius and all his adherents by Nicholas, which disrupted the Greek from the Western Church, took place. Leo VI., the Philosopher, author of the compend, in sixty books, of the laws of the Empire, called after his father "Basilicæ," succeeded in 866, and died in 911, aged forty-six. His indolence, effeminacy, and inefficiency excited disaffection. A conspiracy was formed against him; but, though wounded, he recovered. He was followed by Constantius Porphyrogenitus, a son of his fourth marriage. There was thereafter a rapid succession of emperors, most of whom rose suddenly, lived in the midst of strife, trouble, and conspiracy, generally ending in deposition or assassination, until the famous Italian family Comneni, who had been long resident in the East and had served the Empire with distinction, rose into such power as to be called by the troops to the throne in 1065, and were strong enough to form, at length, a new dynasty as Emperors of Constantinople.

Beyond the Ural Mountains and in the neighbourhood of the Caspian Sea a people of Scythian origin, set in motion by war and want, in 889, left their homes under Almos, made their way through the passes of Krapak, and after a hard struggle reached Pannonia. Almos having accomplished his task resigned the further conquest of the territory they had invaded to his son Arpad. In ten years they had extended their possessions from the Carpathians to Servia, and from the east of Transylvania to the foot of the slopes of Styria. The Magyars chose the family of Arpad as their chiefs, and for more than a century that house retained that honour, exchanging it in 1000 for the higher distinction of kings, which they held for two centuries thereafter. The dominion of Charlemagne had stretched to Transylvania. The Moravian king declined to do homage to Arnulph of Germany. The latter asked the help of the Huns, and by their aid speedily humbled his foe. But when Louis, Arnulph's infant son, succeeded, the Huns rushed into Bavaria, swept over Swabia, fell upon Franconia, reached the Baltic, and wrecked Bremen. For thirty years the Germans paid them tribute to abstain from invasion and inroad. Then they passed the Rhine, and rushed like a hurricane over France, even to the Pyrenees. They turned then to Italy, encamped on the Brenta, and when Berengarius advanced against them, besought leave to retire. He refused, they were desperate, and, inflicting death on 20,000 men, marched on through Italy exposing it to pillage. Reaching Bulgaria, the north-western march of the Eastern Empire, they defeated the Slavonic Christians there, and hurried along to Constantinople, where their ravages were stopped by persuasion and presents. Thinking they might now return to their old operations in Germany they made some furious onsets and got into the heart of Saxony; but Henry I. having captured their prince, compelled a truce for nine years, during which time he prepared the country to cope with them. During his days and those of his son Otho they were kept pretty well in their place. Then Geysa, chief of the house of Arpad and of the Magyars, embraced the Christian religion, was admitted into the fellowship of the church and the comity of nations, and his son Stephen having added Transylvania to his previous territories, received a crown from Pope Sylvester II., and assumed the title and pomp of a king. Twenty of the kings of Hungary belonged to the house of Arpad, and though the Hungarians did not cease from being troublesome, they were no longer looked on as the plague of neighbouring nations.

Russia became known to Europe under her Scandinavian princes. The Eastern Slavs who had gradually settled down in the lands around Novgorod and Kieff, being much exposed to the attacks of warlike neighbours and troubled with petty intestine dissensions, sent an embassy to the Varangians or sea-kings of the Norman coast, desiring them to send a chief who should take the government of their confederation. Rurik accepted the invitation. At the head of a small army, accompanied by his brothers Sindf and Truvor, he took possession (862) of the land south of the Gulf of Finland, and the great lakes near it, and laid the foundations of the monarchy of Russia at Novgorod (864), putting an end to the Slavic insurrections against him as an invader by slaying their heroic leader Vadim—theme of many a folk-song—with his own hand, and calling in colonies of Varangians to settle in and help to control the country. Seeing his success, another Varangian band, who had set out to besiege Constantinople, renounced their scheme, settled among the Slavic tribes about the Dnieper, and made their capital Kieff under Oskold. Rurik, having for some time reigned peacefully, died 879, leaving a son Igor, under the regency of Oleg, as his successor. Oleg negotiated the union of the Novgorod and Kieff settlements as one kingdom, made the latter the capital, subdued the neighbouring tribes, and kept the Byzantine emperors at bay. Igor's widow Olga, on his death (945) ruled well and wisely. In 953 she was baptized by the Patriarch of Constantinople, and resigned in favour of Sviatosleff her son, who was, though a warlike pagan monarch, murdered by a neighbouring tribe. Among his three sons the principality was divided, and civil war arose. At length "sunny Prince Vladimir," the youngest son, became sole sovereign, and Russia's golden period—now embalmed in lyric and legend—had come. He was glorious at home, successful in war, famous for valour, and knightly in courtliness. He was baptized into the Greek faith, 988, and the whole nation followed their sovereign to the font. At Kieff a metropolitan bishop was settled and spiritual guidance supplied. Vladimir too divided the principality among his four sons, and again civil war ensued. Jaroslaff, the Justinian of the Slavs, to whom the legal code of Russia is due, emerged successful. After his death (1054), however, nearly four centuries of anarchy divided and disorganized the principality—petty state at war with petty

state, and princelet against princelet—so that in the perilous period of Europe's transition state Russia had no power.

After the death of Charlemagne the empire, which his strong hand with difficulty held together, tottered, as we have seen, under the impotent sway of his successors; and with the extinction of his legitimate descendants it expired altogether. When the Goths, Burgundians, Franks, and Lombards founded kingdoms in the countries formerly subject to the Roman Empire, they did not extirpate the conquered race, neither did they transform the Romans into Germans by forcing on them their manners, constitutions, and laws. In the Frank Empire there never was a uniform mode of dividing the land. Almost the whole of the Frank acquisitions, within what had been Roman territory, were from preceding Germanic conquerors, and a species of confiscation of the property of the dominant race may have superseded the original divisions. Certain it is that the Franks acquired lands in their career of victory, and equally certain that we find Romans living and holding property among them. Thus in the middle ages, in the same city, the Lombard lived under the Lombardic, and the Roman under the Roman law. The races lived together and preserved their separate manners and laws. From this state of society arose civil rights (*i.e.* personal rights or personal laws) in opposition to territorial laws. At first two laws only were admitted: the law of the conquering race and the law of the conquered—in Spain, the Visigothic and Roman laws; in the Burgundian state, the laws of the Burgundians and the Romans. But when a Germanic kingdom subdued and incorporated other Germanic states into it, the laws of the conquered German races were acknowledged in the same way as the Roman had been formerly. Thus, in the northern parts of France, the Frank and Roman laws would be at first exclusively received; but under the Charlemagnic dynasty it would become necessary to admit likewise the laws of the West Goths, Burgundians, Alemans, Bavarians, and Saxons, because these, as nations, belonged to the empire. The law by which an individual should regulate his dealing and assert his rights was that of descent; but with the following exceptions:—The clergy, whatever their parentage, were bound to live according to the law of the church, which was framed upon the Roman law; a woman was bound by the hereditary law of her husband so long as he lived, but after his death she reverted to her own hereditary law; a natural child was left free to choose its own law.

The predominant form of the judicial tribunals necessarily varied in different parts of the immense territory which had been united under the sceptre of Charlemagne, according as the Roman or Germanic ingredients of society predominated. Within the territories of the Roman Empire the civic or municipal constitution was all-pervading. Within Italy the municipal magistrates had the jurisdiction, only a limited right of appeal to the governor of the province, and to the central authority in Rome, being competent. The immediate effect of the institution of the new Germanic states was to subvert entirely the great public institutions of the realm; but, with the exception of the transfer of property and the substitution of personal for territorial laws, all local institutions were left much as they had been. In all districts in which public officers of the state had discharged judicial functions, German officials superseded Roman ones.

The nature of the sovereign authority during this period, though precarious in its possession and extent, was uniform in its character. A kingdom was in those days the territories possessed by a king as over-lord. The sovereign was he who possessed territories not held of any over-lord, and who had vassals within these territories holding of him. He might hold other territories as a vassal, without lowering his character as sovereign. Hence we find the boundaries and the constitutions of kingdoms shifting and fluctuating.

The constitution of all the Germanic states in the provinces of Rome were somewhat as follows:—At the head of the state was a king, succeeding by hereditary right in a certain family, without, however, any exact observance of lines of descent, primogeniture, and nearness of relation. In each province of the kingdom an officer, combining the judicial and civil powers of the Rector with the military functions of the *Comes* of the Roman Empire, was appointed by the king, and responsible to him. The title of this functionary in German was *Graf*. The Graf managed the military affairs. He also exercised judicial authority, within those cities which had not been Roman municipalities. In the Roman municipalities, from the beginning, the old jurisdiction and civil government of the Romans continued under Charlemagne. In all the Germanic states where the Roman institution of municipal government survived, the Roman mode of taxation was retained. Royal officers or assessors were made responsible to the Graf for the full amount of the assessment within their municipality, and the Graf to the king for the full amount of the assessment within his county. In the other Germanic kingdoms the royal revenue consisted of the produce of the crown-lands, and annual presents from the principal men of the state—a class among which we have the first rude germs of what subsequently developed itself into the feudal system.

The personal followers of the warrior leaders among the Germanic tribes were rewarded in these new kingdoms, not by gifts of movable property, but by the assignment of the use of portions of land so long as they continued faithful. This mode of redistributing territory laid the foundations of the feudal system, and the holders of these territorial grants became rapidly, though almost insensibly, the most powerful body in the kingdoms. The son of one of these great tenants of the crown, of ripe years and military ability, naturally stepped into the extensive feudal holdings of his father, as well as his allodial or freehold property; and when (as was almost always the case) that father held the office of count (*graf*), or frontier-count (*mark-graf*), or general (*herzog*), the son also succeeded to the office. Thus men came to regard feudal tenures as equally permanent with allodial property; the possession of allodial property as implying equally with that of feudal, allegiance to the chief of the state; and the tenure of large properties of either or both kinds as inseparable from the tenure of state offices, to which their holders were in the habit of succeeding at the same time. As the wealth and power of this class increased, so did its ambition. The history of the middle ages is, in so far as the sovereigns are concerned, a series of attempts on the part of these nobles to found and extend feudal kingdoms. The success of the Normans greatly encouraged such aspirations. Under their name are included hordes of marine adventurers, collected from the desperadoes of every Germanic tribe; but the most noted in history are the families of Rollo and Robert Guiscard. The former obtained extensive settlements in France, and united under one sceptre the whole of the lands formerly divided among the petty kings of the Saxon Heptarchy. (See "History of Great Britain and Ireland," Chapters III. and IV.) The same sea-roving warriors entered the Mediterranean, and plundered Galicia in 844. They subsequently landed in Andalusia, but were defeated by the Moors at Seville, under Abdurrahman. Having forced their way into this great sea they wasted the shores of Spain and Africa, ran up the Rhone, swept through the Tyrrhene Sea, put Pisa and Lucca to the flames, and threatened the Greek Empire. Then the Byzantine emperors accepted their aid as a counterpoise to their Arab invaders. The strife of the princes of the empire gave them excellent opportunity for exercising the umpireship of the strong sword, and at length, in the warfare carried on between the Frankish monarchy and the Lombards, they played an active part in Southern Europe. By the Byzantine Greeks they were encouraged to colonize Sicily, and so early as 1029 made settlements on it. In 1046 they entered into alliance with the German emperor; but seven years later Robert Guiscard deemed it wiser to hold all that he had conquered in Apulia, and all that he intended to conquer in Calabria and Sicily, as a fief from the Pope. During the later centuries of this period the mountain chiefs of the Gothic race in Spain gradually reconquered the richer portions of that land from the Arabs, and erected them also into independent kingdoms. Those were all finally united in the hands of Ferdinand and Isabella, and after them came under the sceptre of their successor to the imperial dignity, Charles V.

There was, of course, a great diversity of social character within so wide a range of territory as the empire. In Rome, Italy, and the south of Gaul there was, among the free Roman citizens, with all their feebleness of character, considerable refinement of habits and some inclination towards literary pursuits. Among the provincial Romans there was greater rusticity—a larger admixture of Celtic and Germanic manners and customs. East of the Rhine and north of the Danube, the population remained very nearly in the rude state described by Tacitus. Boniface, in 724, commenced his mission among the Saxons of Hesse by burning down, with his own hands, the sacred oak under which they were wont to sacrifice, while the terrified inhabitants looked in vain for the supernatural fire that was to avenge the sacrilegious deed. The people were still hunters and tillers of the soil; and the civil organization of the Saxons under Charlemagne had advanced little, if anything, beyond that of the Suevi in the time of Cæsar. The revolution which established several Germanic kingdoms, and finally one Frankish Empire, on the ruins of the Roman dominion, interspersed all these various grades of refinement rudely through each other. Rude Germanic warriors came to reign at Rome amid a high and refined population. Romish priests and captives carried the habits and feelings of the church and the empire far into the innermost recesses of the forest-clad mountain ranges of Bohemia and Thuringia. The Romans lost in refinement and knowledge, but they contracted somewhat of the hardihood of the Teutons. The indigenous Germans lost somewhat of their old simplicity and rude sincerity, but they gained ideas which, stirring in their minds, left them no rest until they had marked out a higher civilization. Advancement in civilization we can scarcely call any progress that took place between the beginning of the fifth and the close of the eighth century, but just as little was it retrogression. The age was energetic and intelligent, though, mainly for want of the means of perpetuation, there was no original work that posterity cared to keep alive: and of science and literature there was little or nothing as yet embalmed in written literature.

Section III.—The Development of the Church.

The church had meanwhile been growing up into a mighty, and, in a great measure, an independent power. Subsequent to the Council at Nice the chief management of church affairs was concentrated in the hands of five patriarchs or metropolitans: the bishops of Constantinople, Rome, Antioch, Alexandria, and Jerusalem. The bishops of Rome and Alexandria declined the Jewish title of Patriarch, and resumed that of Pope, Papa, or Father—a designation which, even subsequent to the overthrow of the Western Empire, was common to many of the western dignitaries of the church, and is still the prevailing designation of the clergy of the Greek Church.

In each of the imperial provinces in which the Germanic kingdoms had been erected the church possessed considerable landed property. The official members of the church were also organized on a system of subordination and disciplinary rule, enforced both by temporal influences and the sanctions of religion. The superior clergy were the most learned men of the time. The Germanic troops garrisoned within the empire at least professed Christianity, and, with the exception of the Franks, the most important of the invading tribes had also been baptized into the church. The newcomers were prepared not only to leave the church unmolested, but even to add to its authority. The temporary heathenism of the Franks ultimately tended to increase the power and dignity of the Roman pontiff, and still more, to promote the unity of the organization, and its subordination to the metropolitan see of Rome. The Goths and Lombards were Arian in faith. The churches within the Roman Empire adhered to the orthodox doctrines. The churches in Gaul were not conciliated by the toleration of their conquerors. They gladly hailed, in their new and somewhat dubious convert, Clovis, an instrument for the subversion of the heretic empire of the Goths, and their influence materially promoted his conquests. He and his successors felt what an important ally they had secured in the Church, and the Frankish monarchs, down to the time of Charlemagne, were, with few exceptions, the patrons and the patronized of the orthodox within their dominions. This drew upon the mighty Charles the eyes of the Bishop of Rome, hard pressed as he was on many occasions by the heretic Lombards, and indignantly defied by the Byzantine emperors. The patriarchate of Rome was offered to Charles Martel, the mayor of the palace, and accepted by his son Pepin. The greater honour of Emperor was reserved for Charlemagne, who naturally sought to reward the services of the Pope by compliances in return. Charlemagne had an additional reason for befriending the Roman court. Rome, so long the seat of empire, was also the seat of learning, accurate business habits, and polished manners. Charlemagne was delighted with the organization of the Roman Church, with the superior learning of its clergy, and the great beauty and decorum of its fine ritual. He struggled hard to assimilate the Frankish churches to it in all these respects; and, in his anxiety to obtain this end, he felt an additional inducement to enforce the authority claimed over them by the Bishop of Rome, besides those which considerations of friendship and gratitude had already created.

By this means, among the churches in the whole of western Europe not in the hands of the Arabs, a greater uniformity and coherence was introduced. The Bishop of Rome was secured in the exercise of that authority over them which he had so long asserted, while Charlemagne's own temporal power and influence were considerably increased. As yet the Pope had obtained no temporal jurisdiction or authority in Rome beyond that which was, from custom, voluntarily conceded by Christian communities to their bishop. But the gift of the Exarchate of Ravenna, by Pepin, confirmed by Charlemagne, had laid the foundation of his claim to be considered as a temporal sovereign. He was most wary, however, in putting forward his claims. The churches throughout the empire of Charlemagne were rapidly advancing in temporal wealth and influence. That monarch adopted a policy naturally suggested by events in the declining Empire of Rome. He conferred such powers upon the bishop in each province as made him an efficient counterpoise to the graf or count. The church had long attempted to establish a claim to the tithes of the faithful on the strength of the Old Testament dispensation. Charlemagne went a step beyond this, and bestowed upon it, as far as his power extended, the tithes of all subjects of the Frankish Empire as well of infidels as of the faithful. In each bishopric large funds in land, and the tithe of all lay property, were allotted to it. The clergy were obliged to live in the house with the bishop, according to the canonical rules; and, where the bishopric was large, affiliated, collegiate, or prebendal, churches were instituted at convenient distances. The dignitaries of these churches were endowed with extensive jurisdiction in secular affairs; and their superiority in learning to the laity occasioned them to engross at court—whither, as holders of large landed estates, they, as well as mere secular dignitaries, were summoned on state business—all those offices to the discharge of which literary acquirements were indispensable. The collegiate and canonical mode of life promoted the ultimate establishment of the celibacy of the clergy; and all those powerful and organized bodies, emancipated from the ties of domestic life, were subordinated to the Bishop of Rome—himself now a territorial sovereign.

The advancement of the church in organization and concentration of power was more decided than was that of the state. As the descendants of Charlemagne became more and more incapable, the papal assertion of temporal territorial sovereignty began to be more boldly advanced on the part of the popes. The final division of the empire, and the perpetuation of a series of mere shadows as elective emperors in Rome and Germany, greatly increased the influence of the popes. In the case of narrowly contested elections—and almost all elections were such—the Pope, in whom, by the consent of all, resided the right of crowning the new emperor, could exert a most material influence by throwing his weight into one or other scale. Thus he obtained frequent opportunities of extorting reluctant concessions from anxious candidates. The arrangement, for instance, by which Robert Guiscard in 1053 agreed to hold Apulia, Calabria, and Sicily as a fief of the holy see, contributed much to strengthen the authority of the Pope; and shortly afterwards, under Hilde-

brand, a system of policy was commenced which, more than anything else, contributed to lend consistency and energy to the court of Rome, and to secure for a while concentration of purpose and effectiveness of action. In the face of her Eastern foes the church braced herself to a great task under the astute guidance of Gregory VII.—

> "To place religion on an awful throne,
> Whence kings and nations should receive with awe
> Guidance, rebuke, and life's resistless law—
> An earthly semblance of a heavenly one:
> Such was the purpose which inspired the hand
> And stirred the plotful brain of Hildebrand."

GEOGRAPHY.—CHAPTER XI.

THE PHYSICAL FEATURES OF NORTH AND CENTRAL AMERICA.

THE contour of America is simpler than that of the triple-continent of the eastern hemisphere. South America resembles Africa in its slightly indented configuration and the uniformity of its coast-line. North America is, in its more indented coast-line, liker Europe. To a superficial area of 5,500,000 square miles North America presents a coast-line of about 25,000, while to 5,125,000 South America provides about half that amount of access to the sea.

The continental masses of the New World are very differently constituted and disposed from those of the eastern hemisphere. As a geographical integer, the western continent is composed of two large irregularly triangular masses, joined together by a long narrow isthmus, and it comprises the most lengthy continuous body of land on the surface of the globe.

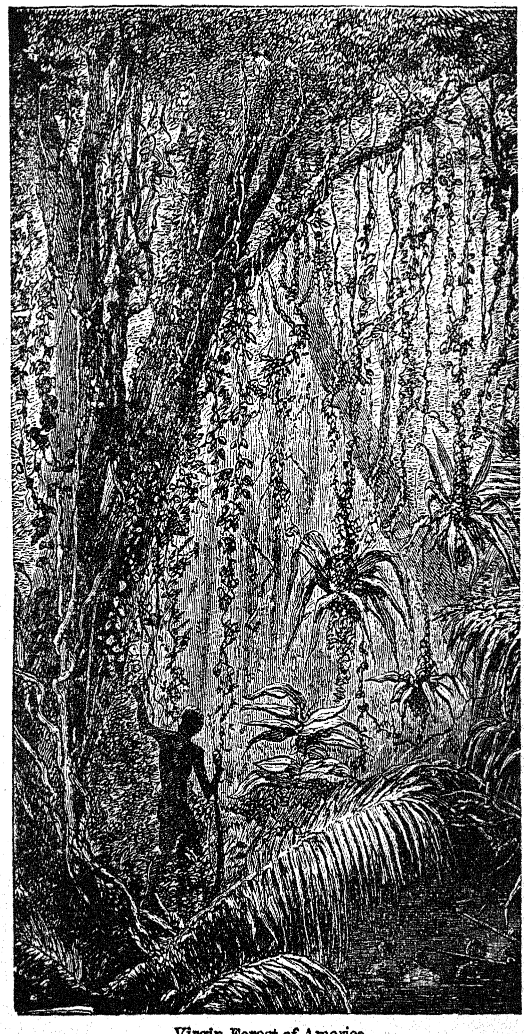
The outward form of North America is that of a triangle, the base of which is the northern coast, the apex the Isthmus of Darien, and the two sides the eastern and western shores. Its physical features include a mixture of the most sublime, romantic, and picturesque scenery which can meet the eye in any quarter of the globe. The alternations of lofty ranges of mountains, magnificent rivers, enormous lakes, boundless forests, gigantic trees, extensive prairies, and foaming cataracts, coupled with the singular appearance of the native tribes, fill the mind of the stranger with wonder, admiration, and interest.

Of the northern portion of this continent, consisting mostly of British America, the most characteristic feature is its vast chain of lakes—by far the largest bodies of fresh water on the globe—terminating in the great river St. Lawrence. These lakes are surrounded by extensive densely wooded forests, consisting chiefly of different species of pines, covering, in many places, rich and luxuriant plains, which stretch far to the north. When these plains are cleared the soil is found to be of surpassing fertility.

The five lakes—Superior, Michigan, Huron, Erie, and Ontario—together with a few smaller and dependent basins, cover an area of nearly 95,000 square miles, of which vast extent Lake Superior alone occupies a surface of 32,000 square miles, *i.e.* only about 2000 square miles less than the superficial extent of England. One-fifth of the entire fresh water of the globe is contained in these immense reservoirs. The slope of the Atlantic water-shed is indicated in the descending steps of these lakes. Superior is 672 feet above the level of the sea; Michigan, 575; Huron, 571; Erie, 555; and Ontario, 289. The two last-named lakes are united by the river Niagara, $33\frac{1}{3}$ miles in length. During that short course it descends in rapids and by the great fall a depth of 162 feet, and then debouches by the St. Lawrence into the sea with a considerable slope. Besides these there are Lake Winnipeg, Reindeer Lake, and Slave Lake, names which indicate the chief members of groups of inland waters covering a vast extent of country. On each side of the Rocky Mountains there are lakes both large and numerous. There are several lakes also in Mexico, though these bear no comparison in superficial extent to those of the great fresh-water inland seas of the north.

The country round Lake Superior, on both the American and British territory, is somewhat cold and dreary. There is a great extent of hill and dale near the lake, and pine-clad mountains rise to the height of 14,000 or 15,000 feet above its surface. Its rugged scenery is described as exhibiting "surprising groups of overhanging precipices, towering walls, caverns, waterfalls, and prostrate ruins, mingled in the most wonderful disorder, and which burst upon the view in ever-varying and pleasing succession."

The north shore of Lake Huron is rocky, in some places destitute of vegetation, and in other parts thickly clad with trees of stunted growth. But, after passing these, marginal forests of fir, spruce, pine, beech, and poplar appear, and the interior in many places presents a very different character, especially on the banks of the numerous tributary streams, where there are frequently to be seen extensive valleys of rich and deep soil, producing maple, oak, elm, birch, and



Virgin Forest of America.

basswood, besides occasional groves of red and white pine of large size. Various places have been cleared and cultivated.

From the east end of Lake Huron a range of mountains, called La Cloche, extends northward, and constitutes the eastern boundary of a table-land, intersected by numerous small lakes and rivers, covered in several parts by extensive forests and marshes, and occupied here and there by a few fur-hunting establishments.

Bounded by the river Ottawa on the east, and included within what might be called an irregular peninsula between lakes Huron, Erie, and Ontario, there is comprised a region nearly identical with Upper or Western Canada. It consists (1) of an extensive plain, adjoining the rivers and lakes, (2) two terraces, and (3) a table-land. The plain extends to about 20,000 square miles of fertile, alluvial, and well-wooded land.

It has an almost uniformly level or slightly undulating surface. There is a remarkable absence of stones. The forests contain trees of the richest foliage. In many places prairies or natural meadows extend for hundreds of miles, covered here and there with clumps of oak, white pine, and poplar, presenting an appearance to which the park of an English nobleman cannot compare in beauty, and as to magnitude it dwindles into insignificance. A delightful climate, combined with these advantages, have led to extensive colonization in this region.

Between this plain and the high table-land to the north-east there are, as we have said, two terraces or slopes, extending from east to west, and separated by a range of hills. The first terrace is small, and extends to Lake Ontario. It is very fertile and tolerably well cultivated. The northern terrace is the larger of the two, about 50 miles wide, and contains numerous small lakes and a few rivers; its soil is fertile, and offers an ample field for colonization.

The table-land in the northern half of this region is, on an average, about 1300 feet above the level of the sea. It is for the most part covered with wood. Near the centre there are numerous lakes, most of which discharge their waters into the Ottawa or Grand River. Lake Nipissing, near the north-west boundary, covers a surface of 155 square miles.

North-eastward of the junction of the river Ottawa with the St. Lawrence is the region which is specially denominated the Valley of the St. Lawrence, and comprises the whole of Lower or Eastern Canada. Towards the mouth of the St. Lawrence the ground, on both sides, is mountainous and covered with forests. On the north the mountains run parallel with the river till we reach Quebec, when they take a westerly course. On the south the mountains also run for a long way in the same direction as the river, but at a greater distance from its banks than on the other side, and 60 miles below Quebec they run off, in a southerly direction, into the United States. On both sides of the St. Lawrence there is a most beautiful country, not only cleared, cultivated, and thickly settled, but actually adorned with a continuous line of villages on either bank. There is not a point from which the spire of a spacious and elegant church does not greet the eye, and frequently there are many to be seen in the same view. The eastern portion of Canada contains the greatest variety of beautiful scenery—mountain, rock, hill, dale, plain, forest, waterfall, lake, and river.

From the Ottawa to about 30 miles below Quebec the north bank of the St. Lawrence increases in height and boldness, and in the neighbourhood of that city the country is decidedly hilly. To the lowlands, which here and there occur on the banks of the St. Lawrence and its tributaries, succeed, as we go northwards, a series of terraces, next a range of gently sloping hills, and then a mountain chain, beyond which wide regions stretch.

On the south bank of the river, beginning in the west, there is an extensive, and, for the most part, level plain, with a fertile soil and a dense population, occupying a considerable portion of Lower Canada. Down the river the country becomes more hilly, presenting from 16 to 20 miles of a gradual slope towards its banks; it then stretches out into a table-land, and afterwards descends towards the basin of the river St. John. Nearer the peninsula of Gaspé the country is hilly. Southward, towards the commencement of the basin of St. John, the country becomes rugged and elevated, and towards the north and west is separated from the United States by many very high hills.

The province of New Brunswick possesses an alpine character, with rich valleys, sheltered plains, and noble forests, in which many lakes occur, and streams wend in every direction, flowing either into the large river St. John or falling into the Atlantic on the east.

To the south-east of New Brunswick is situated the peninsular province of Nova Scotia. It is pleasantly diversified with hill and dale, intersected everywhere with rivers, and studded with lakes of every size and shape. These occupy such an extent of country as to cover nearly one-fifth of the entire surface of the province.

Lying nearly due north from the great Canadian lakes, and occupying an extensive surface of the north-eastern portion of America, the great sea, called Hudson Bay, penetrates the North American continent. It is connected with the Atlantic by Hudson Strait, and with the Arctic Ocean by Fox Channel. It is about 900 miles long and 600 miles broad. Around this large but generally ice-bound inland sea lie what were formerly the North-western Territories of the Hudson Bay Company—an immense tract of upwards of 3,000,000 square miles, now incorporated into the Dominion of Canada.

This vast territory may be divided into five regions:—

1. *The Eastern or Sterile Region*, which lies between Hudson Bay and the Labrador coast on the Atlantic, and extends southward to a ridge of table-land running nearly south-west to the source of the Ottawa River, which divides the waters which flow into that river and the St. Lawrence from those which flow into Hudson Bay. The west of the sterile region extends from Hudson Bay on the east to the great lakes Athabasca, Slave Lake, and the Great Bear Lake on the west, and to the Arctic Ocean on the north. This extensive tract of country is cold, rugged, and barren; nothing is to be seen but rocks, lakes, swamps, and barren mountains, buried under ice and snow for three-fourths of the year. The climate is rigorous in the extreme, even more so than Greenland is. On that account it is left to the undisturbed possession of the Esquimaux and a few forlorn families of Indians.

2. *The Wooded Region* lies along the south and south-western shores of Hudson Bay. It extends to the northern boundary of Upper Canada and the shores of Lake Superior. At some distance inland from Hudson Bay this region is tolerably well wooded, contains numerous lakes, produces fur-bearing animals, and affords employment to a number of factories, *i.e.* fur establishments.

3. *The Savannah Region* lies to the westward and extends to the base of the Rocky Mountains, and northward to Lake Athabasca and the Peace River. The surface is mostly a level plain, much intersected by rivers running in deeply cut channels. Its soil produces a thick grassy sward, which furnishes abundant food to numerous herds of buffaloes and several kinds of deer.

4. *The Region of the Mackenzie River* stretches north of Lake Athabasca, and lies between the Sterile Region on the east and the Rocky Mountains on the west. The valley of the river extends 2 or 3 miles from its banks, till about 90 miles from its mouth. There it spreads out into a delta of from 15 to 40 miles in width, and is intersected by various affluents of the Mackenzie River. The banks of that river are alluvial and pretty well wooded.

5. *The Rocky Mountains and the Columbia Region* lies between these mountains and the ocean. The granitic mountain chain of the Rocky Mountains runs parallel to the Pacific Ocean, and bounds the region of Columbia on the east and north-east. Their average height is 8500 feet, though some peaks rise to the height of 15,000 to 16,000 feet; their width is from 50 to 100 miles. The country, which commences at the western base of these mountains, is an uneven plain, with an average width of 100 miles. A great portion of this plain is covered with lakes and swamps, but the vegetation in summer is very luxuriant. Along the coast of the Pacific the country is very mountainous, and the isolated peaks of the chain are covered with snow for a great part of the year. The natives of these dreary regions experience much wretchedness.

To the west and north-west of Columbia a large peninsula stretches between the Pacific and the Polar Sea, terminating at Behring Strait on the west. It is dreary and unproductive, inhabited by tribes of Indians, and is mainly valuable from its producing fur-bearing animals.

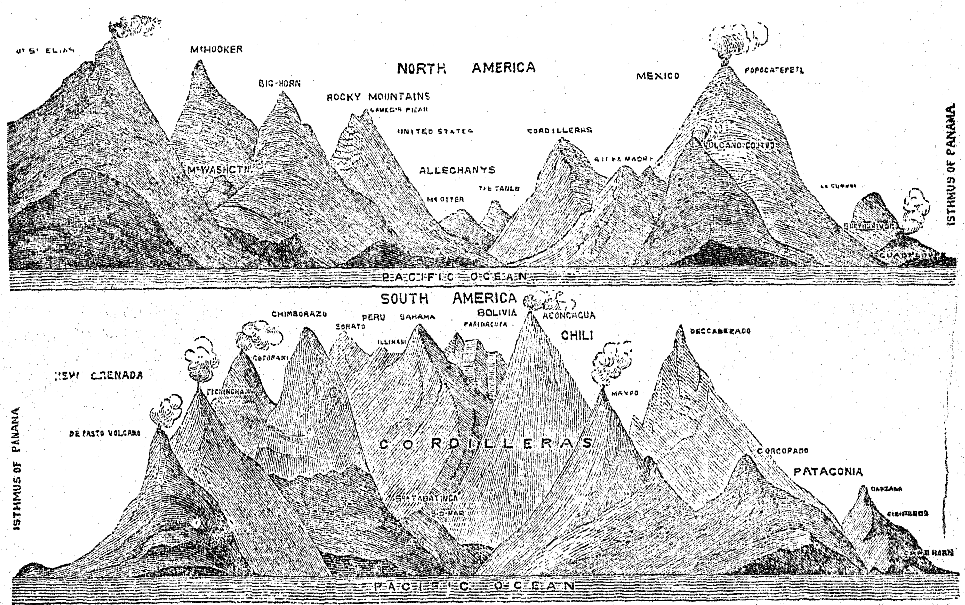
The vast portion of North America occupied by the United States stretches across the whole continent, from the Atlantic to the Pacific, and from the great Canadian lakes, the upper portion of the river St. Lawrence, and, further westward, from 49° N. lat. on the north to the Gulf of Mexico on the south. This immense territory is traversed by two ranges of mountains, which divide it into three regions:—(1) The Appalachian chain, including the Alleghany Mountains, running in several ridges nearly parallel to the Atlantic

coast, in north-easterly and south-westerly directions, to a distance of 1200 miles; and (2) the chain of the Rocky Mountains (whose northern termination we have already described). This is a continuation of the high lands of Central America and Mexico. It stretches northward, parallel to the Pacific coast, and presents a much grander scale of elevation than that of the Appalachian system.

The Appalachian Mountains form the great water-shed or dividing line between the waters which flow eastward into the Atlantic Ocean and those which flow westward into the Mississippi. They cover an area of about 100 miles in breadth, only one-third of which is occupied by the mountain chains, the rest consisting of intermediate valleys, in which numerous rivers flow. These mountains run at very unequal distances from the coast. In some parts towards the north the Atlantic almost washes their base, while towards the south, in the Carolinas and Georgia, it is about 200 miles distant.

The region (3) between these mountains and the Atlantic coast includes the older States of the Union, where civilization and agriculture have made the most progress. It is intersected by numerous rivers, none of which, however, from their short courses, are of any great magnitude. The land on the sea-coast is level, and much indented by numerous bays and gulfs; the soil is generally sandy, and in many parts barren, except on the banks of the rivers, where it often exhibits an extraordinary degree of fertility. As we recede from the coast the country becomes greatly and agreeably diversified with hills and valleys, the latter of which possess a rich and fertile soil. Towards the south the plain adjoining the coast presents a boundless monotony of forests, swamps, marshes, and fields which are for the most part extremely barren. The region between these two mountain systems is the valley of the Mississippi, a river draining a surface of upwards of 1,000,000 square miles of country, and the second in extent in the world.

The Appalachian chain of mountains slopes on the west by a gentle but broken descent to the Mississippi, a region with no elevation but gently rising hills, upwards of 1000 miles in length, and about 300 miles in width, deeply furrowed by numerous rivers over its whole surface. Near the mountains the country is wild and broken, in some parts fertile, but generally barren. The whole of this vast territory was originally an immense natural and unbroken forest, interspersed here and there, on the western side of the Alleghanies, with open and naked plains, called prairies, clothed with grass, herbage, and flowers, and presenting, in the month of May, the most enchanting scenery. Many clearings have been effected since in this vast stretch of trees by the indefatigable industry of the Saxon and the Celt.



Comparative Height of American Mountains

On the eastern side of the Mississippi we have a champaign country, with occasional hills of moderate elevation, covered with pine forests, and interspersed with swamps, open prairies, and inundated marshes, a considerable portion capable of cultivation, and much of it rich and fertile.

The region west of the Mississippi for a considerable distance from its banks partakes of the character of the eastern side. It consists of an immense plain, divided into pine woods, prairies, lakes, swamps, and hickory and oak lands. Westward we reach wide-spreading steppes, clear of wood, scorched in summer with intense heat and in winter subject to intense cold, produced by the winds from the Rocky Mountains. Northern Texas and the upper regions of the Arkansas are analogous in their physical aspect to the high plateaus of the Asiatic continent, while the country stretching along the base of the Rocky Mountains, of an average width of 500 or 600 miles, is called emphatically *the desert.* The name of *savannahs* is given to those vast prairies of the western region which display a boundless ocean of verdure, and deceive the sight by seeming to rise towards the sky, and of which the only inhabitants are immense herds of bisons or buffaloes. In the country west of the Mississippi wood is comparatively scarce, and in the arid and desert plains to the east of the Rocky Mountains only a few trees are to be seen on the banks of the rivers. Many parts of the states of Arkansas, Missouri, and Iowa are very fertile and cultivable, a large portion of the land being of very superior quality.

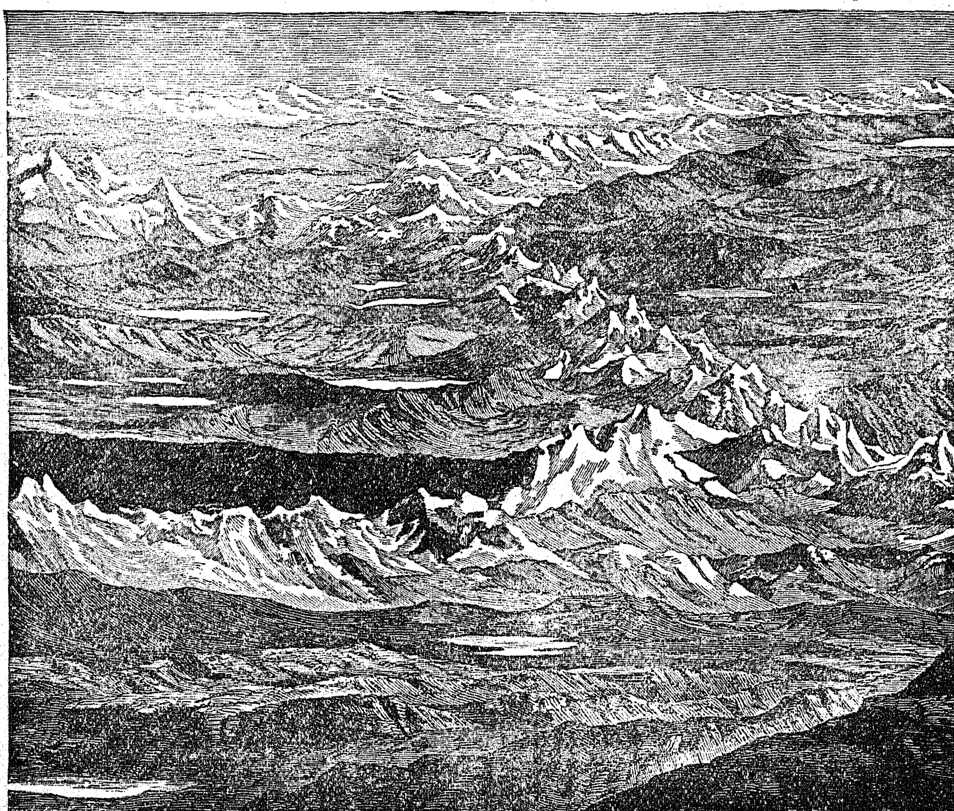
In the Rocky Mountains the innumerable streams which run eastward to feed the great Mississippi and Missouri rivers take their rise. This gigantic range divides the eastern territories of the United States from California and Oregon —two states which lie between this mountain range and the Pacific coast. This mountain chain, which has a breadth of from 50 to 100 miles, rises abruptly from the Plains of Texas, some of the peaks being visible at the distance of 100 miles. The western or Pacific declivity is not so abrupt as the eastern; and towards the north, where they constitute the eastern boundary of the Oregon territory, both sides, instead of passing into plains, terminate in hilly regions of considerable extent. Among the ridges and peaks there occur, towards the south, many wide and fertile valleys; but towards the north, deep and precipitous ravines, covered with dense and gloomy forests; and particularly towards the western

side, wide depressions in the hilly regions and well-watered prairie lands occur.

Two ranges of mountains, which run nearly parallel to the coast—the Blue Mountains and the Cascade Mountains—divide the Oregon territory into three regions. Between the Blue and Rocky Mountains is arid, barren, and uninhabitable—by those who depend on the soil for subsistence. The general appearance of the country for some distance from the coast is flat, but it gradually rises from hills of moderate elevation to rocky snow-clad peaks of a great height. The whole of Oregon is drained by the river Columbia and its tributaries, on the banks of which the only fertile land is found. The valley of this river comprises all the open space between the Rocky Mountains and the Pacific. Here, as well as in many other places along the coast, wood is abundant, some of the trees reaching an enormous size. Pine trees are found 300 feet in height, with a circumference of from 36 to 45 feet, presenting a solid trunk of upwards of 170 feet without a single protruding branch. In the interior there are extensive plains or prairies without wood. These are covered with grass, and spangled in spring with a profusion of beautiful flowers. The climate among the mountains in the interior is severe in winter, and deficient of rain and moisture in summer; but towards the coast it is much milder than in the same latitude on the Atlantic coast.

The physical features of Oregon nearly apply to the neighbouring territory of California—a country which is situated between Oregon and Mexico, and divided into Upper and Lower California. The former is adjacent to Oregon, and consists of a strip of flat, sandy, barren soil, extending along the Pacific coast and inland to the distance of 100 to 200 miles. Then we have a mountain range, and after that, as we proceed eastward, we reach the valley of the river Colorado. The Tule Lakes occupy the north-eastern extremity of the territory. In the rainy season they occupy a surface of 100 miles in length. The surface of Upper California is, to a great extent, covered with rocky mountains, and possesses but a small portion of fertile soil. Where it is arable it is unusually rich.

Lower California is almost wholly high, bare, rocky, and barren, with many ravines, and few plains or spots capable of cultivation. The aspect of the country, which greatly resembles Upper California, is wild and sterile.



Panorama of the Central Andes.

The most remarkable feature in the physical aspect of the southern portion of North America—the apex of the triangle to which we compared that continent—is the extensive plateau or table-land which occupies the greater portion of Mexico and of Central America. On the east and west the coasts are low. Journeying into the interior the land begins to ascend, to all appearance, in a succession of lofty mountains. But the whole interior is, in fact, really elevated from 4000 to 8000 feet; and it forms the loftiest plateau in the world—the capital town, Mexico, being situated 7000 feet above the ocean. The eastern declivity of the southern portion of the plateau, next the Mexican Gulf, makes a continual and rapid descent; but the western slope, towards the Pacific Ocean, alternately ascends and descends through several remarkable longitudinal valleys. The table-land of Mexico Proper, on the contrary, descends very rapidly towards the Pacific, but more gradually towards the Mexican Gulf.

The shores of Yucatan exhibit a sandy and flat plain, extending a considerable distance inland. Further north, on the western coast of the Gulf of Mexico, this level plain, composed of alluvial soil, is covered with a thick luxuriant forest, stretching inland from 50 to 120 miles, and often liable to be inundated; further north still, the eastern coast is low and sandy. Behind this low and level coast, at the distance of 60 to 180 miles from the sea, the country gradually rises to the bottom of an extremely steep ascent, which leads to the high table-land on the west. This ascent rises in some places in terraces; in others it ascends from 5000 to 6000 feet in a distance of less than 10 miles in width. The outer edge, towards the east, is lined by a continuous series of hills, two of which rise to upwards of 13,000 and 17,000 feet. These plains are divided by two ranges of mountains, which traverse them in an eastern and western direction,

and they occupy by far the greatest part of the surface of Mexico.

Central America is a narrow, twisted strip of land lying between the Isthmus of Panama or Darien and that of Tehuantepec, extending about 1200 miles north-west to south-east, and varying in width from 20 to 360 miles. The Andes continue their course through it in a varying mass of table-lands and mountains. Physically it is divisible into three sections—(1) Guatemala ("tree-covered land"), a table-land consisting of verdant plains of great extent, 5000 feet high, but intersected by deep valleys. In the north the Cerro Pelado, a series of parallel mountain ridges, forms the junction between Northern and Central America, and the grassy hill-slopes of Mexico and Guatemala merge into one another about 95° W. lon. The two cities of Old and New Guatemala are separated by an interval of 12 miles. The former lies at the foot of the Volcano de Agua—a perfect cone, green to its very top, whence issue occasionally torrents of boiling water and showers of stones; the latter has on its western side the high picturesque volcanic spires of Pacaya, Fuego, and Agua, ranging from 7000 to 10,000 feet. (2) The plain of Nicaragua and Honduras, where a break in the great Andean chain occurs, manifesting itself in plain and lake, covering an area of 30,000 square miles, little more than 120 feet above the Pacific level. Mosquito Land and the Honduras are for the most part table-land and mountain-peak, many of the latter being volcanoes. (3) The plain of Panama and the table-land of Costa Rica. The former is very little raised in surface above the sea-level, though it is studded here and there with hill ranges; the latter is a high table-land encompassed by volcanoes, and between these is the Cordillera of Veragua, a vast stretch of forest highway. Across the Isthmus of Panama a railway has been constructed from Colon (or Aspinwall) to Panama in a single line 47 miles long, reaching an elevation of 250 feet. Along pretty nearly the same route a ship canal is being carried, with a total length of 46 miles, between the bays of Limon and Panama, to form a great sea-way from ocean to ocean.

Central America has, of course, few rivers of magnitude. The San Juan forms the outlet of the Lake of Nicaragua, which discharges its waters by this channel from its south-east corner into the Caribbean Sea. The San Carlos and the Serapique are tributaries of the San Juan. The Rio Dolce carries the waters of the Gulfo Dolce into the Gulf of Honduras. Besides the lakes already mentioned we may note Peten, near Yucatan, 70 miles in circuit; Atitlan, 50 miles; and Guixar, near San Salvador, 80 miles.

Politically the name Central America is not so extensive in its application as it is physically. It comprehends the six States of (1) Guatemala—bounded N. by Yucatan, W. by Mexico, E. by Honduras and San Salvador, S. by the Pacific; area, about 40,000 square miles. (2) San Salvador, bounded W. by Guatemala, E. by Honduras, and S. by Forseca Bay, which also separates it from Nicaragua; area, 7300 square miles. It was originally named *Cuscatlan, i.e.* the land of riches. (3) Honduras, bounded W. by Guatemala and San Salvador, E. by the Caribbean Sea, and S.E. by Nicaragua; area, 40,000 square miles. At the Cape of Honduras Columbus first touched the American mainland (1502). (4) British Honduras, or Belize, an area of about 20,000 square miles, under the government of Great Britain, bounded W. by Guatemala, N. by Yucatan, and E. by the Gulf of Honduras. (5) Nicaragua, bounded W. by the Pacific, N. by Honduras, E. by the Caribbean Sea, and S. by Costa Rica; area, nearly 50,000 square miles, consisting of the natural divisions (i.) Mosquito Land, moist, covered with forest-growths, rich in animals, and, commercially speaking, mainly valuable for mahogany and india-rubber; (ii.) a central zone where great grassy plains abound, and cattle, horses, mules, &c., are bred; and (iii.) the Lake District, where the depression of the great American plateau supplies the bed of the land-locked Lake of Managua, and the island-dotted Lake of Nicaragua, which is fed by the Mayales and Malacoloja rivers on the north, the Frio on the south, and empties itself by the rapid-broken San Juan into the Caribbean Sea. (6) Costa Rica, bounded N. by Nicaragua, W. by the Pacific, E. by the Caribbean Sea, and S. by Panama and Colombia; area, 20,000 square miles. On the slope towards the Atlantic great forests are found. The table-lands and plateaus are broad, differ greatly in height, and are pretty well cultivated. Animal and vegetable life take wide ranges, and though gold, silver, and copper are the only mines yet worked, the region is rich in iron, zinc, nickel, and lead. Marble also abounds. It is divided into six provinces: San Jose, Cartago, Heredia, Alajuela, Guanaxaste, and Puente Arenas. To the east of Costa Rica, between 77° to 83° W. lon., the state of Panama extends, occupying the isthmus of that name. Its area is nearly 30,000 square miles. In the west of it is Picacho, 7200 feet, the highest peak of the mountain chain which forms the dividing land between the Atlantic and the Pacific oceans, and across it the interoceanic canal is being cut.

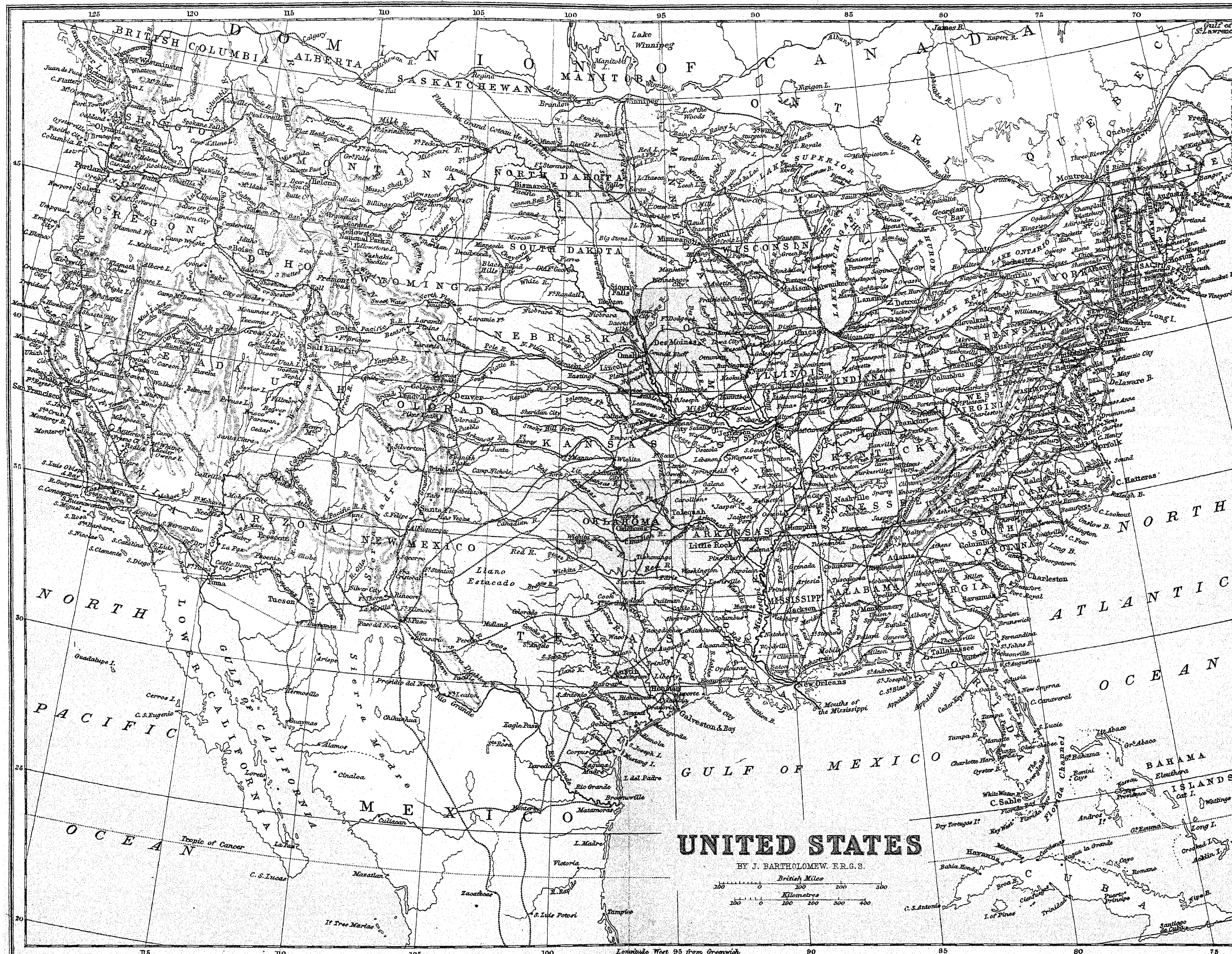
The general aspect of the West Indian Islands is mountainous, many of the mountains affording striking proofs of their volcanic origin. They all possess a soil of extraordinary fertility, and abound with almost every kind of tropical production.

THE FRENCH LANGUAGE.—CHAPTER XII.

ADVERBS, THEIR USES, CLASSES, SIGNIFICATION, AND POSITION —EASY LESSONS IN READING—EXERCISES IN COMPOSITION AND SPEAKING.

SECTION I.—ADVERBS.

ADVERBS may be regarded as abbreviated forms of expression modifying words or phrases, which, though contributing greatly to compactness of composition and brevity of style, are not, except in the case of a very few of the primary ones, essential parts of speech. We might, as experiment would easily show, more readily dispense with the use of adverbs than with any other class of words; as, *utilement*, *grandement*, signify *d'une manière utile*, in a useful way; *d'une manière grande*, in a grand style. We can thus either say *Mon devoir sera fait avec soin*, or *soigneusement*, My task shall be done with care, or carefully. In even more difficult cases the same fact may be brought out; *e.g.* in *Il sortit de chez le roi*, He went *out* of the king's house, the adverbial phrase is equal to *de la demeure royale*. The more specific adverbs also, such as *ici*, here; *là*, there; *où*, where; *quand*, whence, &c., may be regarded as equal to *ce lieu-ci, ce lieu-là, quel lieu? quel temps?* &c. *A droite*, on the right, *à gauche*, on the left, are abbreviated forms of *à la main droite*, on the right hand, *à la main gauche*, on the left hand, and so on. It is, however, of great advantage to the harmony of language, as well as lucidity of expression, that we should have some means of dispensing, when advisable, with small words, like prepositions and determinative adjectives or pronouns, and have a choice of forms of expression which shall enable us, in speech, to emphasize the special meaning we desire to have attached to our words. Besides, as they are neither varied for gender, number, or person, adverbs can frequently be so used as to avoid awkwardness of phrase, indistinctness of reference, and difficulties of pronunciation. It is of great importance in the study of any language, but especially in that of French, in which monosyllables have such a tendency to crowd together in groups, and in which it is so desirable to observe at once euphony and perspicuity, to acquire a proper knowledge of the general and special meanings of adverbs, their proper and possible places, and the delicacies and peculiarities of their idiomatic uses. Yet it is far from easy to supply by written rule precise instructions in the use of a class of words in which, while the necessity of combining pleasantness of sound with accuracy of reference must be recognized as paramount, the specific idioms of adverbial usages, and the fineness, if not the finesse, of good taste—that almost instinctive elegancy and excellency of expression which characterizes refined minds—must also receive attention. Every one can perceive at a glance that the sentence, *Non-seulement Turenne était un grand général, mais encore un philosophe vertueux*, is neither so pleasing in expression nor so precise in reference as *Turenne était non-seulement un grand général*, &c., Turenne was not only a great general, but also a virtuous philosopher.



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One distinction between adverbs would, if attended to, we think, greatly help the learner. Adverbs are really of two main sorts, differing very materially from each other. The adverbs of the one class not only *modify* the signification of some other word, but add a distinct notion to it; thus, *Le lion rugit*, The lion roars, is an unmodified sentence, but *Le lion rugit avec fureur* (*i.e. furieusement*), The lion roars with fury (or furiously), is modified by addition. The adverbs of the other class *limit*, restrict, intensify, or specialize the signification of the word or words which they qualify; as, *Il est parti hier, il reviendra demain*, He left yesterday, he will return tomorrow; *Vous viendrez d'abord chez moi*, You will first of all come to me. The first class might be called *notional*, because they add to the full sense of a sentence some additional notion, element, or complement; and the second sort might be regarded as *relational*, determinative, or auxiliary, because they so modify the statement made in a sentence as to bring that sentence more clearly and nearly into relation with the actual facts at once of reality and of thought; *e.g. Il sent cette offense* is a distinct sentence, but we add something to it when we say, *Il sent vivement cette offense*, He feels this injury keenly; but in the sentence, *L'âne est aussi humble, aussi patient, aussi tranquille, que le cheval est fier, ardent, impétueux*, The ass is as humble, patient, and quiet as the horse is proud, eager, and hasty, we do not *add* anything to the nature of the idea, but merely correlate or *bring into comparison* the two sets of qualities mentioned.

Owing either to the inherent difficulty of the subject, or to the idea that little or nothing requires to be known or can really be advantageously taught regarding the use of adverbs, this part of speech has not unfrequently received less attention than it deserves and requires. We shall endeavour to give such a comprehensive view of the nature and uses of adverbs as shall considerably enlarge the usual scope of teaching, and be of important use to the diligent and intelligent student.

An adverb is an uninflected word used to modify the meaning of verbs, adjectives, and other adverbs; as, *Parlez peu, réfléchissez beaucoup*, Speak little, think much; *L'écureuil est un petit animal très-vif*, The squirrel is a very lively little creature; *Le temps passe très-rapidement*, Time passes very quickly. It receives its name from its being more especially employed with verbs, and it may generally be regarded as equivalent to a preposition followed by a noun. In the phrases, *Parler poliment*, To speak politely; *S'habiller modestement*, To dress modestly, *poliment* signifies *avec politesse; modestement, avec modestie*. Or, to take a different illustration, instead of saying *Vivre dans la tranquillité*, To live in tranquillity; *Marcher avec lenteur*, To walk with gentleness; *Écrire avec vitesse*, To write with swiftness; *Parler d'une manière hardie*, To speak in a bold manner; *Etre riche à excès*, To be rich to excess, we can say, *Vivre tranquillement*, To live quietly; *Marcher lentement*, To walk slowly; *Ecrire vite*, To write swiftly; *Parler hardiment*, To speak boldly; *Etre trop riche*, To be too rich. Some adverbs, however—especially those of place—are capable of being used as the complements of prepositions. We can, for instance, say, *Allez d'ici à Rome*, Go from here to Rome; *Il est venu de là en peu de temps*, He has come from there (*i.e.* thence) in a short time; *D'où venez-vous?* Whence come ye? A very large number of adverbs, particularly those of manner and quality, are formed from adjectives by the addition of the terminal syllable *ment*, just as in English many are formed by adding *ly*. In his "Lectures on the Science of Languages," a celebrated linguist thus felicitously explains the reason for the adoption of this mode of forming adverbs:—"We are told by French grammarians that in order to form adverbs we have to add the termination *ment;* thus from *bon*, good, we form *bonnement;* from *vrai*, true, *vraiment*. This termination does not exist in Latin, but we meet in Latin with expressions such as *bonâ mente*, in good faith. We read in Ovid, *Insistam forti mente*, I shall insist with a strong mind or will, I shall insist strongly; in French *J'insisterai fortement*. Therefore what has happened in the growth of Latin, or in the change of Latin into French, is simply this: in phrases such as *forti mente*, the last word was no longer felt as a distinct word, and it lost at the same time its distinct pronunciation; *mente*, the ablative of *mens*, was changed into *ment*, and was preserved, as a merely formal element, as the termination of adverbs, even in cases where a recollection of the original meaning of *mente* (with a mind) would have rendered its employment perfectly impossible. If we say in French that a hammer falls *lourdement*, we little suspect that we ascribe to a piece of iron a heavy mind."

The following are specimens of this method of forming adverbs:—

Adjective.		Adverb.	
Masc.	Fem.		
Actif,	active,	Activement,	*actively.*
Discret,	discrète,	Discrètement,	*discreetly.*
Doux,	douce,	Doucement,	*sweetly.*
Frais,	fraîche,	Fraîchement,	*freshly.*
Glorieux,	glorieuse,	Glorieusement,	*gloriously.*
Haut,	haute,	Hautement,	*emphatically.*
Public,	publique,	Publiquement,	*publicly.*

But the following adjectives change final *e mute* into *e* acute (*e*):—

Aveugle,	aveuglément,	*blindly.*
Commode,	commodément,	*conveniently.*
Conforme,	conformément,	*conformably.*
Enorme,	énormément,	*enormously.*
Incommode,	incommodément,	*inconveniently.*
Opiniâtre,	opiniâtrément,	*obstinately.*
Uniforme,	uniformément,	*uniformly.*

Traître makes *traîtreusement*, treacherously, and *vite* is used as an adverb just in its simple adjective form.

Impuni	makes	impunement,	*with impunity,*
Beau	"	bellement,	*softly,*
Fou	"	follement,	*foolishly,*
Mou	"	mollement,	*effeminately,*
Nouveau	"	nouvellement,	*newly,*

the four last taking their adverbial form from their feminines *belle, folle, molle, nouvelle.*

These adverbs are generally formed (1) by the addition of the syllable *ment* to the masculine of adjectives ending in *e, é, i*, or *u*; as adj. *facile*, easy; *utile*, useful; adv. *facilement*, easily; *utilement*, usefully; *aisément*, easily; *poliment*, politely; *ingénument*, ingenuously.

(2) In adjectives terminating in a consonant we add the syllable *ment* to the feminine; as adj. *généreux, généreuse;* adv. *généreusement*, generously; adj. *heureux, heureuse;* adv. *heureusement*, happily.

The adjectives *commun*, common; *confus*, confused; *importun*, importunate; *obscur*, obscure; *précis*, precise; *profond*, deep, take an acute accent on the *e* of the feminine termination when forming an adverb; as, *communément*, commonly; *confusément*, confusedly, &c.

(3) In adjectives ending in *ant* and *ent*, the final *nt* is changed into *m* before adding *ment;* as *élégant*, elegant, *élégamment*, elegantly; *constant*, constant, *constamment*, constantly; *prudent*, prudent, *prudemment*, prudently; *décent*, decent, *décemment*, decently.

Adjectives in *ant* derived from verbs are seldom used in forming adverbs; thus *charmingly* cannot be rendered in French by a single word, but an equivalent to it must be found; such as *d'une manière charmante.*

Exercise.—Form adverbs having the meaning characterized by the quality indicated by the following words—

Générosité, prudence, honnêteté, patience, modestie, vaillance, facilité, vigueur, audace, attention, éloquence, cruauté, mystère, violence, rapidité, régularité, soin, négligence, constance.

Adjectives are sometimes used adverbially, and when thus used are *always* in the masculine singular—*e.g.*

parler haut,	*to speak loudly.*
frapper ferme,	*to strike hardly.*
sentir bon,	*to smell nicely.*
chanter faux,	*to sing out of tune.*

The following adjectives are those most frequently used in

this way, with examples of the kind of verbs with which they are so used—viz.

bon, mauvais, *with* sentir, *to smell.*
bon, *with* tenir, *to stand fast.*
cher, *with* couter, acheter, vendre.
clair, *with* voir (mostly in a literal sense).
court, *with* demeurer (*to stick fast*), couper (*to cut short*).
droit, *with* marcher, *to go ahead.*
exprès, *on purpose, with* faire, venir.
faux, *incorrectly;* juste, *correctly; with* chanter, *to sing.*
haut, *loud;* bas, *low; with* parler, *to talk.*
juste, *with* raisonner, deviner.

Those adverbs which are not formed from adjectives are, for the most part, indeclinable compounds; as *demain*, to-morrow; *souvent*, often.

Adverbs are either (1) simple, *i.e.* consisting of a single word, as *bien*, well; or (2) compound, *i.e.* consisting of two or more words, as *de bonne foi*, sincerely.

1. Simple Adverbs.

The principal simple adverbs may be arranged in the following seven classes—viz.

1. *Time.*—Adverbs of time determine the present, past, or future time of the action expressed by the verb; they answer to the question "when?"

alors,	*then.*	environ,	*about.*
après,	*afterwards.*	hier,	*yesterday.*
aujourd'hui,	*to-day.*	jadis,	*of yore.*
auparavant,	*before.*	jamais,	*never.*
aussitôt,	*immediately.*	longtemps.	*long ago.*
autrefois,	*formerly.*	lors,	*then.*
bientôt,	*soon.*	maintenant,	*now.*
déjà,	*already.*	naguère,	*lately.*
demain,	*to-morrow.*	parfois,	*betimes.*
depuis,	*since.*	quelquefois,	*sometimes.*
désormais,	*henceforth.*	souvent,	*often.*
dorénavant,	*henceforth.*	tantôt,	*sometime.*
encore,	*still, again.*	tard,	*late.*
enfin,	*lastly.*	tôt,	*soon.*
ensuite,	*afterwards.*	toujours,	*always.*

2. *Place.*—Adverbs of place serve to express the difference of distance and situation, with relation to persons and things.

ailleurs,	*elsewhere.*	dessus,	*above.*
alentour,	*around.*	devant,	*before.*
auprès,	*near.*	ici,	*here.*
avant,	*before.*	là,	*there.*
céans,	*here.*	loin,	*far.*
dedans,	*within.*	partout,	*everywhere.*
dehors,	*without.*	près,	*near.*
derrière,	*behind.*	proche,	*nigh.*
dessous,	*under.*		

3. *Manner.*—The adverbs of manner express how and in what manner things are done, either (1) absolutely, or (2) comparatively. They are usually formed from adjectives.

ainsi,	*thus.*	mal,	*ill.*
aussi,	*also.*	mieux,	*better.*
bien,	*well, very.*	pis,	*worse.*
comme,	*like.*	plutôt,	*rather.*
ensemble,	*together.*	surtout,	*above all.*
exprès,	*purposely.*	vite,	*quickly.*
gratis,	*freely.*	volontiers,	*willingly.*

4. *Quantity.*—Adverbs of quantity indicate some increase, diminution, excellence, or perfection in the action or quality which they modify; and indicate difference of degree in objects which we compare one with another.

assez,	*enough.*	plus,	*more.*
autant,	*so much.*	presque,	*almost.*
beaucoup,	*much or many.*	quelque,	*some.*
davantage,	*more.*	si,	*so.*
fort,	*very.*	tant,	*so many.*
guère,	*little.*	tout,	*all.*
moins,	*less.*	très,	*very.*
peu,	*little.*	trop,	*too much.*

Adverbs of quantity, when placed before substantives, require the preposition *de* after them, thus—

il n'a pas beaucoup de patience,	*he has not much patience.*
n'avez-vous pas assez de pain?	*have you not bread enough?*
il y a plus de quarante ans qu'il est mort,	*it is more than forty years since he died.*
il fit l'opération en moins de dix minutes,	*he performed the operation in less than ten minutes.*

But *bien*, meaning much, many; and *la plupart*, the most part; require the definite article also after *de*.

il a bien de la patience,	*he has much patience.*
bien des personnes,	*many persons.*
bien du monde,	*much company.*
la plupart des hommes,	*most men, many men.*

5. *Negation.*—Adverbs of negation are words that are made use of for denying and refusing.

ne,	*no, not.*	nullement,	*no indeed.*
non,	*not at all.*	peut-être,	*perhaps.*

6. *Affirmation.*—Adverbs of affirmation indicate assent, consent, admission, or agreement.

certes,	*assuredly.*	oui,	*yes.*
certainement,	*certainly.*	vraiment,	*truly.*
même,	*even.*	volontiers,	*willingly.*

7. *Interrogation.*—Adverbs of interrogation express or imply questioning or inquiry.

combien?	*how much (or many)?*	où?	*where?*
		pourquoi?	*why?*
comment?	*how (in what manner)?*	quand?	*when?*

Some of these adverbs may be used in different meanings, and they may therefore fall under several divisions, according to their position and meaning in a sentence, such as *davantage, bien*, &c. Not only so, but several words can be employed *either as adverbs, prepositions, or conjunctions*, and therefore great care requires to be taken that, in the use of these parts of speech, one is not confounded with the other.

The student is recommended now to re-read the chapter on forming negative and interrogative sentences. (Chap. X., pages 594, 595). To what has been there said we may now add the following further hints and cautions:—

Of the two parts of a negative adverb *ne* always precedes the verb. The other part usually follows it; as *Je ne sais pas*, I do not know.

Ne . . . que means "nothing except." The *que* in this phrase immediately precedes the excepted word; as *Je n'ai gagné que deux sous*, I have earned nothing except a penny (*i.e.* only a penny).

When a verb is the excepted word *faire* requires to be introduced before *que*; as *Il ne fit que chanter*, He only sang.

Ni is used in alternatives; as *Je n'ai vu ni son père ni sa mère*, I have neither seen his father nor his mother. In such sentences as *Je ne l'ai pas vu—ni moi non plus*, I did not see it—nor I, "nor" equals "and not."

But with the infinitive both negatives more elegantly precede the verb; as *Il était attentif à ne pas blesser des convenances*, He was careful not to shock the proprieties.

Pas is very commonly omitted after *pouvoir, savoir, cesser, osser*, and *bouger*. The addition of *pas* after these words conveys a slightly different meaning; as *Il ne cesse de neiger*, It is always snowing; *Il ne cesse pas de neiger*, It snows still.

In compound tenses the negative goes with the auxiliary; as *On ne m'aurait pas cru*, People would not have believed me.

Ne without *pas*, and with no negative meaning, is used with *que* in a subordinate clause, depending on *craindre, appréhender, avoir peur, trembler*, in an affirmative principal clause, and is then, as *que . . . ne*, equal to "lest;" as

"Il a peur que ce dieu dans cet affreux séjour,
D'un coup de son trident ne fasse entrer le jour."

(He is afraid lest this god should shed daylight
With a blow of his trident into this haunt of fright.)

Ne is suppressed when *rien, personne, aucun* are used without a verb; as *Qui arrive? Personne.* Who has arrived? No one.

Pas and *point* are frequently omitted, for the sake of brevity, after the verbs *pouvoir, oser, savoir;* as *Cela ne se peut,* That cannot be; *Il n'ose le faire,* He dares not do it.

Two negatives may be used without, as in English, the latter destroying the former; as *Nul autre ne fut,* No other was; *Il ne dort ni nuit ni jour,* He sleeps neither night nor day; *Je ne vois pas non plus,* I do not see either.

The negative *ne* is used after *à moins que, plus que, mieux que, depuis que, autrement que, avant que, craindre que, avoir peur que, empêcher que, appréhender que, s'en falloir que, ne douter pas que;* as *A moins que vous ne l'y engagiez il ne la fera pas,* He will not do it unless you engage him to it; *C'est bien pire qu'on ne le disait,* It is much worse than they said.

Comparison of Adverbs.

Many adverbs are compared just as adjectives are—as, *doucement,* sweetly; *plus* (or *moins*) *doucement,* more (or less) sweetly; *le plus* (or *le moins*) *doucement,* most (or least) sweetly.

The following adverbs are compared thus:—

Positive.		*Comparative.*		*Superlative.*	
bien,	*well.*	mieux,	*better.*	le mieux,	*best.*
mal,	*ill.*	pire,	*worse.*	le pire,	*worst.*
peu,	*little.*	moins,	*less.*	le moins,	*least.*
beaucoup,	*much.*	plus,	*more.*	le plus,	*most.*

They require to be carefully distinguished from the corresponding adjectives, which are—

bon,	*good.*	meilleur,	*better.*	le meilleur,	*the best.*
mauvais,	*bad.*	pire,	*worse.*	le pire,	*the worst.*
petit,	*little.*	moindre,	*less.*	le moindre,	*the least.*

The student should remember that *Plus mauvais, le plus mauvais, plus petit, le plus petit,* are more in use than *pire, le pire, moindre, le moindre.*

2. Compound Adverbs.

Compound adverbs consist of two or more words. They are frequently adverbial phrases; as, *A l'improviste,* unexpectedly; *sur-le-champ,* immediately; *sans cesse,* incessantly; *en général,* generally; *tout-à-fait,* quite.

Compound adverbs serve as signs of comparison, and in them the word *que* corresponds to the English word *than* or *as*—

plus . . .	que	*more than.*
moins . . .	que	*less than.*
autant . . .	que	*as much as.*
si	que	*as . . . as.*
aussi . . .	que	*as . . . as.*

Plus que lui, more than he; *moins que moi,* less than I; *Marie n'est pas si grande que Louise,* Mary is not so tall as Louisa.

The principal compound adverbs may be arranged, as the simple ones were, into seven classes. The more important, for the sake of bringing them into relation, in thought, with the simple adverbs, will be found given in classes below, but an extended alphabetical list is given further on for purposes of general reference:—

1. *Time.*—

d'abord,	*at first, immediately*	tout-à-fait.	*entirely, quite.*
une fois,	*at once.*	tout de suite,	*presently.*
tout-à-coup,	*all at once.*	tout du long,	*at full length.*

2. *Place.*—

à part,	*aside, separately.*	en deça,	*on this side.*
à *or* au travers,	*rough, cross.*	nulle part,	*nowhere.*
en travers,	*across.*	vis-à-vis,	*opposite.*
çà et là,	*here and there.*	en haut,	*above, upwards.*
quelque part,	*somewhere.*	en bas,	*below, downwards.*

3. *Manner.*—

à la fois,	*at once, instantly.*	de suite,	*one after another.*
à l'envi,	*in rivalry with.*	d'ordinaire,	*mostly, usually.*
à même,	*in one's power.*	à tort,	*wrongfully.*
à regret,	*unwillingly.*	à la hâte,	*hastily, in a hurry.*
d'accord,	*willingly.*	en vain,	*unsuccessfully.*
de même,	*in the same way.*	surtout,	*above all.*

4. *Quantity.*—

au moins,	*at least.*	tout-à-fait,	*quite.*
en sus,	*moreover, besides.*	ni plus ni moins,	*neither more nor less.*

5. *Negation.*—

ne pas,	*not.*	point du tout,	*by no means.*
ne jamais,	*never.*	pas du tout,	*not at all.*
ne point,	*not at all.*		

6. *Affirmation.*—

sans doute,	*doubtlessly.*	peut-être,	*perhaps.*
à coup sur,	*assuredly.*		

7. *Interrogation.*—

But as there are a very large number of adverbial phrases which are not easily found except in large and costly dictionaries, we supply below an alphabetical list which will be found of great use for reference when reading. The student will observe that some of these sentences can be used either adverbially or *prepositionally:*—

Adverbial Expressions.

A bon droit,	*deservedly.*
A bon marché,	*cheap.*
A cela près,	*that excepted.*
A contre cœur,	*against one's will.*
A contre sens,	*the wrong way.*
A contre temps,	*unseasonably.*
A corps perdu,	*headlong.*
A côté, à part,	*aside.*
A dessein exprès,	*purposely.*
A foison,	*in plenty.*
A fond,	*thoroughly.*
A haute voix,	*aloud.*
A l'abandon,	*in disorder.*
A la Française,	*after the French fashion.*
A la hâte,	*in haste.*
A l'amiable,	*amicably.*
A la mode,	*after the fashion.*
A l'Anglaise,	*the English fashion.*
A la suite,	*afterwards.*
A la traverse,	*unluckily, untowardly.*
A l'avenir,	*for the future.*
A l'entour,	*round about.*
A l'envers,	*the wrong side out.*
A l'envi,	*in emulation.*
A peu près,	*thereabouts.*
A plus forte raison,	*much more so.*
A propos,	*seasonably.*
A quoi bon ?	*to what purpose?*
A rebours,	*the wrong side up.*
A reculons,	*backwards.*
A tâtons,	*groping.*
A tort et à travers,	*at random.*
A tous égards,	*in every respect.*
A tout bout de champ,	*at every turn.*
A toute heure,	*every hour.*
Au plus vite,	*with all speed.*
Au surplus,	*besides, furthermore.*
Autant,	*as much.*
A vue d'œil,	*visibly.*
Bon gré mal gré,	*whether one will or not.*
Cà et là,	*to and fro.*
Combien ?	*how much?*
Comme il faut,	*suitably.*
Dans huit jours,	*in a week.*
Dans quinze jours,	*within a fortnight.*
D'abord,	*at first.*
D'aujourd'hui en huit,	*this day week.*
D'aujourd'hui en quinze,	*this day fortnight.*
D'aujourd'hui en un mois,	*this day month.*
D'autant moins,	*so much the less.*
D'autant plus,	*so much the more.*
De bon cœur,	*heartily.*
De bonne foi,	*fairly.*
De bonne heure,	*early.*
De côté et d'autre,	*up and down.*
De deux jours l'un,	*every other day.*
De fond en comble,	*from top to bottom.*
De front,	*abreast.*
D'heure en heure,	*hourly.*
De jour,	*in day time.*

De jour en jour,	*from day to day.*
De loin,	*afar off.*
De même,	*in the same manner.*
De mieux en mieux,	*better and better.*
De part et d'autre,	*on both sides.*
De pis en pis,	*worse and worse.*
De plein pieds,	*on the same floor.*
De plus en plus,	*more and more.*
De point en point,	*minutely, in detail.*
De prime abord,	*at first sight.*
Depuis longtemps,	*for a long time.*
Depuis peu,	*lately.*
De temps en temps,	*now and then.*
En arrière,	*backwards.*
En badinant,	*for fun.*
En haut,	*upwards.*
En moins de rien,	*in a trice.*
En nulle manière,	*in no wise.*
En plein jeur,	*in open day.*
En un clin d'œil,	*in the twinkling of an eye.*
Enfin, au moins, à moins,	*at last, at least.*
Environ,	*about.*
Ici autour,	*hereabouts.*
Ici près,	*hard by.*
Il y a un an,	*a year hence.*
Il y a aujourd'hui un an,	*this day twelve months.*
Il y aura demain huit jours,	*it will be a week to-morrow.*
Il y eut hier huit jours,	*it was a week yesterday.*
Jusqu'à quand?	*how long?*
Jusqu'ici,	*as far as here.*
Jusqu'où,	*how far.*
Jusque là,	*as far as there.*
Là bas,	*yonder, down there.*
L'un dans l'autre,	*on an average.*
Ni plus ni moins,	*neither more nor less.*
Par ci par là,	*here and there.*
Par dessus le marché,	*into the bargain.*
Par malice,	*through ill nature.*
Par mégarde,	*through mistake.*
Par terre,	*on the ground.*
Pas à pas,	*step by step.*
Pêle-mêle,	*helter-skelter.*
Peu à peu,	*by little and little.*
Plus qu'il n'en faut,	*more than is necessary.*
Pour l'ordinaire,	*in general, commonly.*
Presque jamais,	*hardly ever.*
Sans y faire attention,	*inconsiderately.*
Sans y penser,	*unawares.*
Sens dessus dessous,	*topsy-turvy.*
Tant,	*so much.*
Tant mieux,	*so much the better.*
Tant pis,	*so much the worse.*
Tant soit peu,	*ever so little.*
Tante que,	*as long as.*
Tantôt,	*by and by.*
Tôt ou tard,	*sooner or later.*
Tour à tour,	*by turns.*
Tous les jours,	*every day.*
Tout à coup,	*on a sudden.*
Tout à la fois,	*all at once.*
Tout à l'heure,	*directly.*
Tout au plus,	*at most.*
Tout bas,	*with a low voice.*
Tout de bon,	*in good earnest.*
Tout de suite,	*just now.*
Tout d'un temps,	*at the same time.*
Tout droit,	*straight on.*
Tout d'un coup,	*all at once.*
Ventre à terre,	*at full speed.*
Vis-à-vis,	*opposite.*

EXERCISE.—The student is strongly advised to arrange the foregoing adverbs into classes similar to those shown in the preceding lists, and to study carefully the peculiarity of the meaning of each. He will thus greatly increase the readiness of memory in their use which is so important in endeavouring to speak a language.

EXERCISES IN COMPOSITION AND SPEAKING, INCLUDING INCREASE OF VOCABULARY.

1. Add the following names of animals to the phrases undergiven:—

Cet animal est, This animal is; *Avez-vous vu*, Have you seen? *Connaissez-vous*, Do you know? *Voilà*, There is; *Voici*, Here is; *Voulez-vouz acheter*, Will you buy? *Tu recevras*, Thou shalt receive; *Pourquoi n'as-tu pas vu*, Why hast thou not seen? *Pourriez-vous reconnaître*, Could you recognize? *N'est-ce pas*, Is not this? *Je crois que j'ai vu*, I think that I have seen; *Tout le monde a vu*, Everybody has seen; *N'ai-je pas vu*, Have I not seen?

2. Change *un* or *une* into *le* or *la*, and arrange these names in sentences thus: Le (*or* la) . . . . est un (*or* une) quadrupède; Le (*or* la) . . . . est un (*or* une) bipède, reptile, oiseau, &c.

Un quadrupède,	*a quadruped.*	Un bélier,	*a ram.*
Un bipède,	*a biped.*	Une brebis,	*a ewe.*
Un cheval,	*a horse.*	Un taureau,	*a bull.*
Une jument,	*a mare.*	Une vache,	*a cow.*
Un âne,	*an ass.*		
Un baudet,	*a donkey.*	Un paon,	*a peacock.*
Un mulet,	*a mule.*	Un oiseau,	*a bird.*
Un chien,	*a dog.*	Un aigle,	*an eagle.*
Une chienne,	*a bitch.*	Un vautour,	*a vulture.*
Un chien de chasse,	*a sporting dog.*	Un faucon,	*a hawk.*
Un lévrier,	*a greyhound.*	Un cigne,	*a swan.*
Un chat,	*a cat.*	Un dindon,	*a turkey cock.*
Une chatte,	*a she-cat.*	Une dinde,	*a turkey hen.*
Un éléphant,	*an elephant.*	Une oie,	*a goose.*
Un lion,	*a lion.*	Un canard,	*a duck.*
Une lionne,	*a lioness.*	Un coq,	*a cock.*
Un tigre,	*a tiger.*	Une poule,	*a hen.*
Un hyène,	*a hyena.*	Un poulet,	*a chicken.*
Un léopard,	*a leopard.*	Un faisan,	*a pheasant.*
Un loup,	*a wolf.*	Une perdrix,	*a partridge.*
Un renard,	*a fox.*		
Un sanglier,	*a wild boar.*	Un poisson,	*a fish.*
Un cochon,	*a hog.*	Une baleine,	*a whale.*
Une truie,	*a sow.*	Un requin,	*a shark.*
Un chameau,	*a camel.*	Un esturgeon,	*a sturgeon.*
Un dromadaire,	*a dromedary.*	Un saumon,	*a salmon.*
Un ours,	*a bear.*		
Un cerf,	*a stag.*	Une grenouille,	*a frog.*
Un veau,	*a calf.*	Un lézard,	*a lizard.*
Un agneau,	*a lamb.*	Un serpent,	*a serpent.*
Un mouton,	*a sheep.*	Une vipère,	*a viper.*

SPECIAL USES OF ADVERBS.

Plus and *davantage*, though each signifies *more*, cannot be used indiscriminately: *plus* is followed by *de* or *que*; *davantage* is used alone, and it is put at the end of a sentence; as

Il a plus de fortune que moi,	*he has a larger fortune than I.*
Je suis plus heureux que lui,	*I am happier than he.*
Vous avez beaucoup d'argent, mais il en a davantage,	*you have much money, but he has more.*

In making comparisons, *aussi*, *autant*, are used both in affirmative and negative sentences, but *si*, *tant*, only in negative ones; as

Il est aussi riche que vous,	*he is as rich as you.*
Il n'est pas si (*or* aussi) tard que vous,	*he is not so late as you.*
J'ai autant de livres que lui,	*I have as many books as he.*
Votre frère n'a pas tant (*or* autant) de livres que moi,	*your brother has not so many books as I.*

Plus tôt, in two words, is an adverb of time, signifying *plus vite*, sooner; *plutôt*, in one word, is an adverb of quantity, denoting preference and signifying *rather*; as

Il est arrivé plus tôt que vous,	*he has arrived sooner* (*in time*) *than you.*
Plutôt mourir que de se rendre,	*sooner* (that is, *rather*) *die than surrender.*

Aussitôt que, *dès que*, *quand*, must always, in French, have the future when speaking of things to come, although after them in similar sentences the present tense in English is used.

Il nous l'enverra aussitôt qu'il l'aura fini,	*he will send it to us as soon as he is done.*
Prêtez-le-moi quand vous l'aurez lu,	*lend it to me when you have read it.*

After *peut-être*, perhaps, and *aussi*, so that, the French verb takes the interrogative form, although its meaning is affirmative.

Peut-être viendra-t-il ce soir,	*perhaps he will come to-night.*
Il a été très-mal reçu, aussi a-t-il bien promis de ne plus y retourner,	*he has been very ill received, in consequence of which he has sworn never to go there again.*

Bien is used in two ways: (1) when placed *before* the word it qualifies, it gives emphasis, and means *quite, very, decidedly, much;* (2) when placed after the word it qualifies, it has the simple or primary meaning—*well.* Thus the meaning of *assez bien* and *bien assez* is quite different, as may be seen in these examples:—

Votre thème est assez bien fait,	*your exercise is pretty well done.*
J'en ai bien assez,	*I have quite enough of it.*

Bien moins and *moins bien* are also notably different in signification; as

J'en voudrais bien moins que cela,	*I should desire much less of it than that.*
Ceci est moins bien fait que ce que vous aviez fait d'abord,	*this is not so well done as what you did at first.*

Note also the distinctly different significations of *bien fort* and *fort bien;* as

Il parle bien fort,	*he speaks very loudly.*
Il parle fort bien,	*he speaks very well.*

Tout à coup signifies *soudainement*, suddenly; *tout d'un coup* signifies *tout en une fois*, all at once; as

Sa maison est tombée tout à coup,	*his house fell down suddenly.*
Il devint pauvre tout d'un coup,	*he became poor all at once.*

The adverbs *plus, moins, si, aussi*, &c., require to be repeated before each of the words which they modify; as

Saint Louis était plus éclairé, plus juste et plus vertueux que ses contemporains,	*Saint Louis was more enlightened, more just, and more virtuous than his contemporaries.*
Richard Cœur-de-Lion était aussi brave et aussi intraitable que le fut Charles XII., roi de Suède.	*Richard Cœur-de-Lion was as brave and unmanageable as Charles XII., king of Sweden.*

The repetition of other adverbs must be carefully avoided.

On the place of adverbs in a sentence the following general statement may be here advantageously made :—Simple adverbs are *generally* placed (1) after the verb in simple tenses; and (2) in compound tenses, after the auxiliary; as

Le soleil brille aujourd'hui,	*The sun is shining to-day.*
Le rossignol chante admirablement,	*The nightingale sings admirably.*
Vous êtes en retard,	*You are late.*
Je pense souvent à eux,	*I often think of them.*
L'avez-vous jamais vu?	*Have you ever seen him?*
Charles a beaucoup travaillé.	*Charles has worked very much* [*i.e.* very hard.]

Bien, mal, mieux, jamais, and *trop*, however, when used with a verb in the present of the infinitive generally precede it; as, *Se bien conduire*, To behave oneself well; *Se mal porter*, To bear oneself ill; *Ne jamais mentir*, Never to lie.

Compound adverbs are *always* placed (1) after the verb in simple tenses; and (2) in compound tenses generally after the participle; as,

EXAMPLES.

Ils s'habillent à la Française,	*They dress after the French manner.*
Je l'ai fait à la hâte,	*I did it hastily.*

But in using compound tenses of verbs, we may sometimes place the adverb either before or after the past participle. Thus we may say with equal accuracy—

Il a grandi prodigieusement, *or* Il a prodigieusement grandi,	*He has grown prodigiously.*

Adverbs of *order* or *place*, and those which denote *time* in a *determinate* manner, may be in general put either before or after the verb:—

Nous devons faire, premièrement, notre devoir; secondement, chercher les plaisirs permis,	*We ought first to do our duty; secondly, seek lawful pleasures.*
Aujourd'hui il fait beau; il pleuvra, peut-être, demain,	*To-day it is fine weather; it will rain, perhaps, to-morrow.*

EASY LESSONS IN READING.

It must have been observed by every one who has carefully endeavoured to trace, word by word, the French and English which have been placed side by side as the equivalents of each other that they do not run in precisely the same order, and that there are words in the one which seem to have no distinct individual equivalents or representatives in the other, one seeming to superabound here and the other there. This is the result of what is called the *genius* of the language, and that again is the result of a two-fold cause, (1) the habitual method of thought in a nation, and (2) the peculiar nature of the instrument by which that thought is expressed. Some of these differences of form of expression—which receive the name of *idioms* (Gr. *idios*, private, peculiar), *i.e.* specific peculiarities—are pretty well brought out and exemplified in the following anecdote, which we translate interlinearly as literally as possible, so that these peculiarities may be noted at a glance, and the observant reader may see that he has not always to expect in another language quite the same order of words and forms of phrase to which he has been accustomed in his own. If he gets convinced of this he will be able to free himself of one of the gravest difficulties in the use of French as a language—the idea that the *words* are to be translated in their given or usual collocation. It is not so; the thought is to be expressed in the idiomatic form of expression and collocation which distinguishes each language:—

On demanda à quelqu'un, quel âge il avait? "Ma foi,"
A person asked of some one, what age he was? "My word,"

répondit-il, "je ne le sais point au juste, mais il me semble que
replied he, "I not it know at all exactly, but it, to me, seems that

je puis bien avoir trente-huit ou quarante ans." —"Comment se
I may well be thirty-eight or forty years [*old*]."—"*How does*

fait-il que vous ignoriez votre âge?"—"Monsieur," repliqua-
it happen that you do not know your age?"— "Sir," rejoined

t-il, "je compte mes rentes, mes bestiaux, mon argent; mais pour
he, "I count my income, my cattle, my money; but as to

mes années, je ne les compte jamais: je sais trop bien que je
my years, I not them count ever: I know too well that I

n'en saurais perdre et que personne ne me les
not of them could lose, and that no one from me them

dérobera.
will steal.

If the student now reads the following passages carefully, noticing the differences between the French and the English form of expression, he will find the advantage of it, in enabling him to catch up the mode of French thought, and thence of French idiomatic speech.

La grammaire est une science qui nous enseigne à parler et à écrire proprement une language.	*Grammar is a science which teaches us to speak and write a language correctly.*
L'assemblage des règles établies pour parler correctement une langue, s'appelle grammaire. On dit qu'un homme est bon grammairien, quand il parle bien sa langue. C'est dans la grammaire qu'on apprend l'orthographe, qui est la principale partie de l'écriture. L'orthographe consiste à employer les lettres nécessaires pour former chaque mot.	*The collection of rules established for speaking a language correctly is called grammar. People say that a man is a good grammarian when he speaks his language well. It is in grammar that people learn orthography, which is the chief part of writing. Orthography consists in employing the letters requisite to form each word.*
On écrit en prose ou en vers. La prose est la façon simple, dont on se sert dans la conversation, dans une lettre, dans la plupart des livres. La tournure que chacun emploie en particulier pour s'exprimer, s'appelle style. Le meilleur style est celui dont les phrases sont les plus naturelles.	*People write in prose or in verse. Prose is the simple style which people use in conversation, in a letter, in the greater part of books. The mode of expression which each person employs in particular to express himself is called style. The best style is that of which the phrases are the most natural.*

Le commerce est l'art d'échanger une marchandise contre une autre par voie d'achat ou de vente, dans la vue d'un bénéfice. Bien qu'il ait pour source l'intérêt privé, le commerce est néanmoins le lien de la société, et, grâce à son action bienfaisante, un pays participe aux productions de tous les autres.

Commerce is the art of exchanging one [sort of] goods for another, by way of purchase or sale, in view of [making] gain. Although it has its origin in private interest, commerce is nevertheless the bond of society, and, thanks to its beneficent action, one country shares in the productions of all the others.

Acheter des étoffes, des meubles, des denrées, dans touts les pays, dans toutes les villes du monde, et envoyer, dans ces pays et dans ces villes, des marchandises pour y gagner, c'est faire le commerce, c'est être dans le negoce. Les banquiers commercent en argent, par le moyen des lettres de change.

To buy stuffs, furniture, provisions, in all lands, in every town in the world, and to send into these countries and into these towns goods to make gain there, is to transact business, is to be in trade. Bankers trade in money by means of bills of exchange.

Un négociant est un homme qui envoie dans les pays étrangers, par terre ou par mer, de l'argent ou des marchandises, et qui en fait revenir ou de l'argent ou autre chose pour son profit.

A merchant is a man who sends into foreign countries, by land or by sea, money or goods, and who makes to return (i.e. brings back) from them either money or something else for his profit.

Sans le commerce, nous manquerions de bien des choses qui nous viennent des pays étrangers, et les étrangers manqueraient aussi de tout ce qu'ils tirent de notre pays.

Without commerce we should want many things which come to us from foreign countries, and foreigners would also want everything which they obtain from our country.

NATURAL PHILOSOPHY.—CHAPTER XVIII.

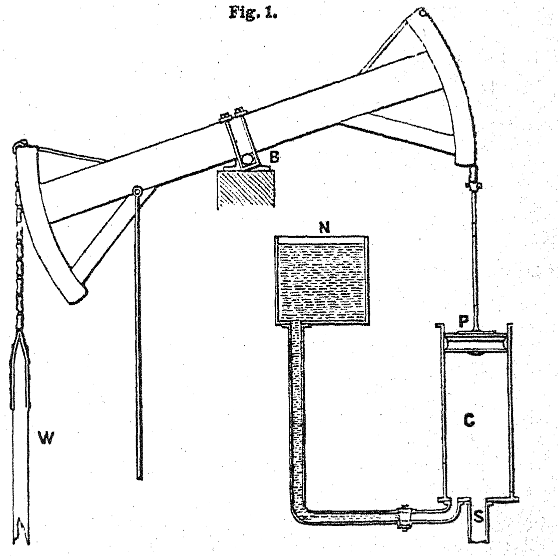
STEAM ENGINE—ATMOSPHERIC CONDENSING ENGINE—ATMOSPHERIC HEAT ENGINE—RADIANT HEAT—SOLAR RADIATION—EFFECTS OF SOLAR RADIATION ON CLIMATE—ANALYSIS OF RADIANT HEAT—ENERGY OF RADIATION—PROPAGATION OF HEAT-WAVES—SOLAR SPECTRUM—HEAT, LIGHT, AND CHEMICAL RAYS—VISIBLE AND INVISIBLE RAYS—CALORIFIC, LUMINOUS, AND CHEMICAL RAYS OF THE SPECTRUM—DECOMPOSITION OF LIGHT BY ABSORPTION—DIATHERMANCY—REFLECTION OF HEAT—REFLECTING POWER OF SUBSTANCES—REFLECTING POWER OF HEAT IN VARIOUS BODIES—REFRACTION OF HEAT—ABSORPTION OF HEAT—ABSORPTIVE POWER OF GASES—RADIATING POWER—ABSORPTIVE AND RADIATING POWER OF BODIES—FORMATION OF DEW—FORMATION OF ICE IN HOT CLIMATES—HOAR-FROST.

STEAM ENGINES.

THE conversion of heat into mechanical energy producing motion, by the combustion of fuel, constitutes the principle of the *heat engine.* Such machines are almost exclusively worked by the expansive force of steam, and their history becomes that of the steam engine. The transformation of heat energy into mechanical power has occupied the attention of practical men for over 200 years, and the comparisons between the engine conceived by Papin in 1690, and the modern locomotive and compound marine condensing engines are sufficient to indicate the vast amount of thought, labour, and skill expended upon the more perfect development of the steam engine.

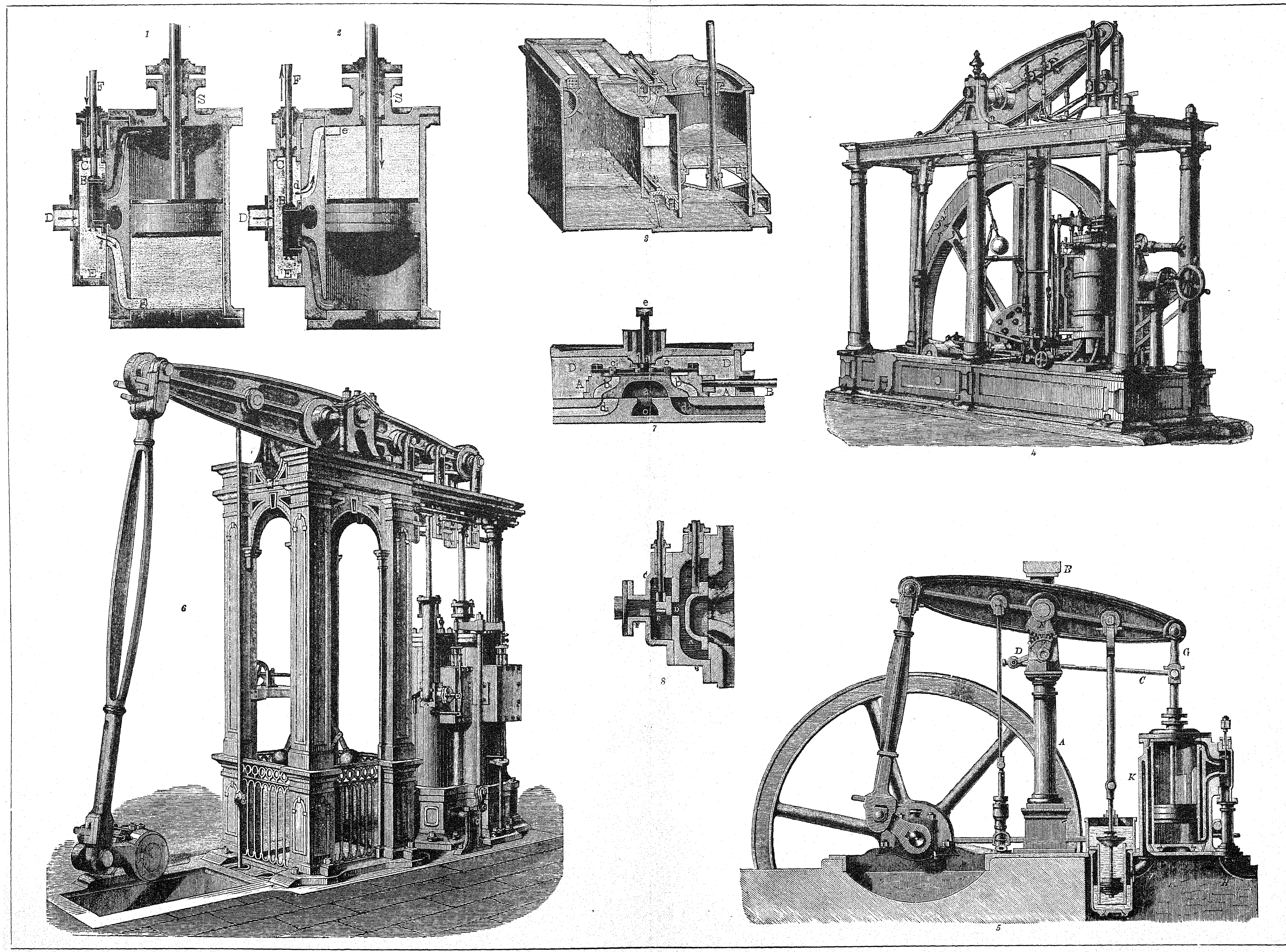
All such machines depend upon the heat of combustion imparted to water contained in a closed vessel, termed a *boiler,* and in which the water is converted into vapour of enormously increased volume under pressure, and the steam is passed from the boiler by a pipe to act alternately upon one side or the other of a piston working in a closed cylinder, which it pushes backwards and forwards by virtue of its great elasticity, the exhausted steam escaping from the cylinder after each stroke by various mechanical arrangements. This up-and-down motion of the piston is either applied direct, as in the power required for pumping, or is converted into a rotatory motion, as in the locomotive, marine, steam crane, and other such engines. In some of the earlier form of engines the energy of the expansive steam was employed for the upward stroke of the piston only, the pressure of the atmosphere being utilized for the downward stroke. Such engines, termed *atmospheric condensing engines,* were long employed for pumping purposes in mines, where a slow and regular motive power sufficed for the work to be performed. The atmospheric condensing engine is shown in fig. 1. The steam, at a low pressure, passes by a pipe, S,

Fig. 1.



from the boiler into the bottom of the cylinder C, and by its expansive force it pushes up the piston P, the rod of which is connected with one arm of the beam B by a chain. As the piston is forced up the arm of the beam rises, from the preponderating gravity of the counter-weight W, attached to the end of the opposite arm of the beam by the chain and rod which carry the plunger and valve bucket of the lift pump. On the descent of the counterpoise W, the bucket descends into the pump-barrel, ready to lift the column of water in the barrel. In this position the beam and piston remain stationary for a moment or two, the steam having been cut off by the action of a lever on the rising of the beam simultaneously with the admission of a jet of cold water from the cistern N into the cylinder by a second lever. On the condensation of the steam by the action of the cold water a vacuum is formed in the cylinder on the under side of the piston, and the external atmospheric pressure drives it down with great force, the pump-rod being raised at the same time. On the piston reaching the bottom of the cylinder steam is again admitted, the atmospheric pressure is balanced, and the upward motion of the piston and subsequent condensation take place. If the piston is made to move through a considerable space a very large amount of pumping work can be performed. It is unnecessary to point out that the alternate cooling and heating of the cylinder at each stroke of the piston produces a great waste of heat and loss of energy, and the condensation of the steam in a separate chamber, by which a double vacuum (both above and below the piston) is obtained, as well as the utilizing of the steam pressure on both sides of the piston, constitute the most important improvements made in 1776 by James Watt, whose name is so intimately associated with the history and progress of the steam engine in this country. These arrangements of a separate condensation chamber, and the double action of the piston, enable the cylinder to be always kept as hot as possible, and the condenser always as cold as possible. Radiation from the heated cylinder into the surrounding air is prevented in the best constructed engines by the use of a steam jacket or a non-conducting envelope.

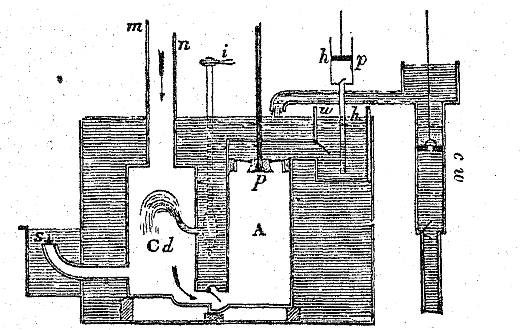
The condensing apparatus and its appendages, as originally designed by Watt, are shown in fig. 2. $c\,d$ is the condenser, into which the used steam passes from the cylinder through the eduction-pipe $m\,n$; A is the air-pump with its piston p, for drawing off the injection water and the water of the condensed steam—it communicates with the condenser by a



1 and 2. Cylinder and Valve-chest. K Piston; G Piston-rod; S Stuffing-box; D Steam-pipe; E Valve-chest; B Slide-valve; F Valve-rod; fg Lower Port and Passage into Cylinder; de Upper Port and Passage; O Passage to Condenser. 3. Condenser and Air-pump. 4. Beam-engine on Watt's System. 5. Another type of Beam-engine. A Supporting Column; B Cross-beam; K Steam-jacketed Cylinder; J Pipe leading to Condenser; C-G Mechanism of Parallel Motion for securing the vertical rectilineal movement of piston-rod. 6. Engine on Woolf's System. 7 and 8. Slide-valves for Expansive Working.

foot-valve, seen in the figure; $h\,w$ is the hot-water well, from which the boiler is supplied by means of the pump $h\,p$—it receives the water drawn off by the air-pump; $c\,w$ is the

Fig 2.



pump to furnish cold water to the condensing cistern, i is the injection cock, s the blow-through valve.

In a high-pressure engine the expansive force of the steam acting upon the piston is considerably greater than the pressure of the atmosphere; the steam consequently has a considerably greater elastic force than in a low-pressure engine. In many high-pressure engines the steam is blown off into the atmosphere and the condensing apparatus dispensed with, and the engine, as a whole, is considerably simplified. All locomotive engines are upon the high-pressure principle.

RADIANT HEAT—SOLAR RADIATION.

The phenomena of radiation scarcely belong exclusively to the science of heat, so intimately are the laws allied to those of sound and light; there are, however, certain important facts connected with the radiation of heat that require to be considered in relation to heat.

All bodies part with their heat in two ways: either by contact with a cold body or by radiation through space. The heat from one end of a rod of iron placed in a fire is slowly conveyed through the substance of the iron to the other end; the heat being communicated by contact, the cold particles of the iron receive the heat from the adjacent hotter particles, and in their turn impart it to colder particles further away, until after the lapse of a sensible time the whole iron of the rod becomes warm. The cold particles at the one end of the rod are not therefore directly or immediately heated from the red end, but derive their heat slowly through the intervention of the intermediate particles.

When a thermometer is passed from the shade into sunshine an instantaneous rise of temperature takes place on exposure to the sun's rays; and as the distance of the sun from the earth is about 93,000,000 miles, and there is no intervening matter through space capable of retaining heat between the earth and the sun, this sensation of heat is transmitted from the sun by a very different kind of action to that by which heat was transmitted through the iron bar, and the action of the sun's heat is as powerful in a cold atmosphere as in a warm one.

It is this heating emanation from the sun and other hot bodies which is called *radiant heat*. The heat to which the thermometer responds is not conveyed to it by conduction through the air, for the air is cold, and the mode in which the heat reaches the body which it warms without warming the air through which it passes is termed *radiation*.

Those bodies which allow radiation to take place through them are termed *diathermanous* bodies; those which do not permit heat to pass through them without becoming themselves hot, are termed *athermanous* bodies, and the heat which passes through the body *radiant heat*.

Three principal sources of heat combine to maintain the temperature of the earth: the heat of the mass of the globe itself, the heat communicated by interplanetary space through which the earth moves, and the heat received from the sun.

All space is incessantly traversed by rays of heat emanating from the most distant orbs and from every particle of matter disseminated through the heavens, and this continual radiation from matter in space gives a certain minute degree of fundamental heat to the earth, independent of that derived from the sun and of that of the mass of the globe.

The regular increase of temperature below the surface of the earth demonstrates the existence of a proper heat belonging to the mass of the earth itself. Fourier has demonstrated that this internal heat is not due to the heating power of the solar rays. The internal heat of the globe is transmitted by conduction to the surface of the earth, the temperature of which, according to calculation, is not raised by more than one thirty-sixth part of a degree centigrade, an amount sufficient in the course of 100 years to melt an envelope of ice some 10 feet thick surrounding the globe. This radiation, and consequent loss of internal heat, would tend gradually to cool down the mass of the earth were it not compensated for by the radiation from the sun.

The solar heat of the surface of the earth produces variable effects, due to the movements of the earth itself. Its revolution on its axis while it revolves round the sun causes different portions of the surface to receive the radiant heat alternately; the variable time for which the sun remains above the horizon, its difference of altitude, and the distance of the earth from the sun not being always the same, combine to render the solar heat a variable quantity. The earth's atmosphere, through which the sun's heat-rays pass, being more or less charged with vapour, also absorbs a variable amount.

The experiments of Pouillet in 1838 determined the amount of radiant heat which the earth receives from the sun and from space. The instrument he employed for these delicate investigations consisted of a brass tube, containing a sensitive thermometer; a longitudinal slit up the tube enabled the height of the mercury to be ascertained. The tube and thermometer were mounted on a stand with a universal joint. At the upper end of the tube was attached a very thin and flat cylindrical vessel of silver, the upper plate of which, when exposed to the sun, was coated over with lamp-black. This vessel was filled with distilled water, the bulb of the thermometer entering the interior of the vessel. At the lower end of the tube a disc of the same diameter as the cylindrical vessel receives the shadow of the latter, and by the coincidence of the two indicated when the blackened surface was exposed normally to the direct action of the solar rays. The temperature of the instrument being first obtained, its blackened surface was then exposed towards a portion of the sky free from clouds, but so that no solar rays fall upon it. After five minutes' exposure the radiation of the instrument causes a certain fall of temperature, which is noted. The blackened disc is then directed towards the sun, and receives the solar heat of the rays in a perpendicular direction for five minutes, when the temperature is again noted. The instrument is then allowed to radiate towards space in its first position for another five minutes, and the final temperature on cooling is taken. The first and third of these observations are necessary to determine the amount of heat imparted to it by the radiation of the instrument into space during the time that it was exposed to the sun, which is the mean of the two degrees of cooling observed. This mean, added to the degree of heat obtained by exposure to the direct rays of the sun, gives the total increase of temperature.

This rise of heat from solar radiation, as indicated by the *pyrheliometer*, depends upon the constant heating power of the sun, the condition of the atmosphere, which can only be regarded as uniform on the day of observation, and upon the altitude of the sun above the horizon, on which depends whether the rays enter the atmosphere obliquely or perpendicularly.

Some of the results deduced by M. Pouillet from a lengthened series of observations are that the radiant heat of the sun, when its rays strike vertically, is equivalent to 17·633 calories per minute to every square mètre of surface,* and therefore that the quantity of radiant heat

* The calorie is the French unit of heat, and is the quantity required to raise one kilogram of water one degree centigrade.

received by the earth and its atmosphere from the sun in one year is about 200 quintillions of calories, an amount so enormous that it is practically beyond conception. It may be expressed in another form by saying that if this heat were uniformly distributed over the surface of the globe it would be capable of melting a covering of ice inclosing the earth $33\frac{3}{4}$ yards thick.

The variable amount of watery vapour or steam present in the atmosphere has an absorbing power on heat about seventy times that of pure dry air, and it is from this cause that the intensity of solar radiation is much greater on the summits of mountains than in the valleys. Although, as higher elevations are attained, the air becomes colder, this arises from the vapour of water at the lower levels arresting a greater proportion of the solar rays than the air in which this vapour is diffused; and the solar rays being composed of two distinct species of radiation—luminous radiations and obscure radiations—the first pass almost entirely through the air to the surface of the earth; the other are mostly absorbed. Therefore, though the atmosphere prevents a large portion of the solar radiant heat from reaching the earth's surface, it compensates for this by retaining those rays which warm itself. Without the presence of the atmosphere and the vapour it contains the radiation of heat from the earth's surface towards space would meet with no impediment, and the loss of heat would be enormous. This is what happens to a certain extent on the mountain top. Immediately after sunset a rapid cooling would succeed to the intense radiant heat of the sun's rays. The effect upon climate of this resistance to the passage of the sun's rays is of immense importance; the intense heat of the desert during the day and the chill at night are chiefly due to the absence of vapours from the air. The severe winters that succeed the scorching summers in the high plains of Thibet are similarly due to the dryness of the atmosphere.

The distinguishing characteristic of radiant heat is that like light it travels in *rays*, which possess all the physical properties of rays of light, and are capable of *reflection*, *refraction*, *interference*, and *polarization*, and they may be separated by the prism into different kinds, as light is decomposed into its component colours. Some of the heat rays are identical with the rays of light, while other kinds of heat-rays make no impression on the eye.

Experiments on the heating effects of radiation prove that not only the sun, but all hot bodies emit rays of heat. If the body is sufficiently hot its radiations become visible, and then it is said to be *red-hot*. If the heat be increased it will radiate not only red rays, but rays of every colour, producing by their combination white rays; it is then said to be *white-hot*. When the body is too cold to appear luminous it still shines with *invisible* heating rays, which are perceivable by a sensitive thermometer, and no substance can be so cold as not to emit radiant heat; but as the eye is sensitive only to particular kinds of rays emitted from very hot bodies, other bodies radiating invisible rays do not appear to shine.

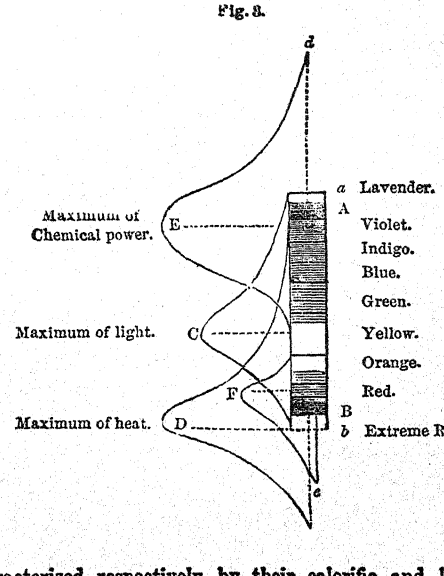
The phenomenon of radiation consists in the transmission of *energy* from one body to another in the form of wave motion, by propagation through the intervening medium, which it traverses with a certain velocity. In the case of *sound* the energy communicated to the air by a vibrating body is propagated through the air, and may finally set some other body, as the drum of the ear, in motion. This sound-energy consists of motion of the air molecules moving to and fro, and producing alternate condensations and rarefactions of the air. The energy due to sound in the air is, however, distinct from that of heat. In a hot body the particles are in a state of intense vibration, and the higher the temperature the more rapid are these vibrations. A diminution in heat means therefore diminished rapidity of vibration of the particles, so that the propagation of heat by conduction through a rod of iron is due to the gradual communication of this vibratory motion from the heated part to the colder portion of the rod. A good conductor consequently is one which takes up and transmits the vibratory motion from particle to particle freely. A bad conductor is one which takes up and transmits the vibratory motion with difficulty.

The propagation of heat by radiation, however, is analogous to that of light. All space, as well as the interstices between the ultimate particles of all matter—the heaviest metal or the hardest crystal—is supposed to be permeated by a medium of vast tenuity termed *ether;* and the particles of a heated body being in a state of intensely rapid vibration, communicate their motion to the ether around them, throwing it into a system of waves or undulations, which travel through space and pass from one body to another with the velocity of light. When these undulatory waves of the ether reach a body, the motion is again delivered up to the particles of that body, which in turn begin to vibrate, and the body becomes heated. It is this passage of vibratory motion through the supposed ether that constitutes radiation, and a ray of heat is simply the direction of the motion of one series of waves.

The analogy between heat and sound and light, as regards its propagation by vibratory motion and undulations, is further established by the difference of *wave-length.* In sound, wave-length defines the *pitch* of the note; with heat, difference of wave-length indicates the particular heat; and with light, wave-length means difference of colour. Thus red, orange, yellow, green, blue, indigo, and violet have all their peculiar wave-lengths. A body when heated emits waves of different length; as its temperature rises other and more rapid vibrations are sent forth with all those previously emitted, so that the motion of each successive temperature is compounded with all preceding ones, and as the union of coloured rays produces white light, the union of the successive heat-waves produces white heat. In a sound-wave the more rapidly the pulses succeed each other, the shorter is the length of the individual wave, and the high or low pitch of a note depends upon the length of the wave and the rapidity of the vibrations.

Newton was the first to demonstrate that a beam of white light was composed of a number of simple tinted rays, among which the seven principal colours are red, orange, yellow, green, blue, indigo, and violet, which, blended together, formed white light. If a beam or pencil of white light is passed through a prism of rock salt, placed with its edge vertical, its direction is changed through a considerable angle of deviation during its passage through this refracting medium, forming, when thrown on a screen, an elongated image or long ribbon showing the above colours, and in which the simple rays are arranged one below the other in the order of their refrangibility, and according to their respective velocity of vibration: this is termed the *solar spectrum.* In this spectrum will be found rays which are

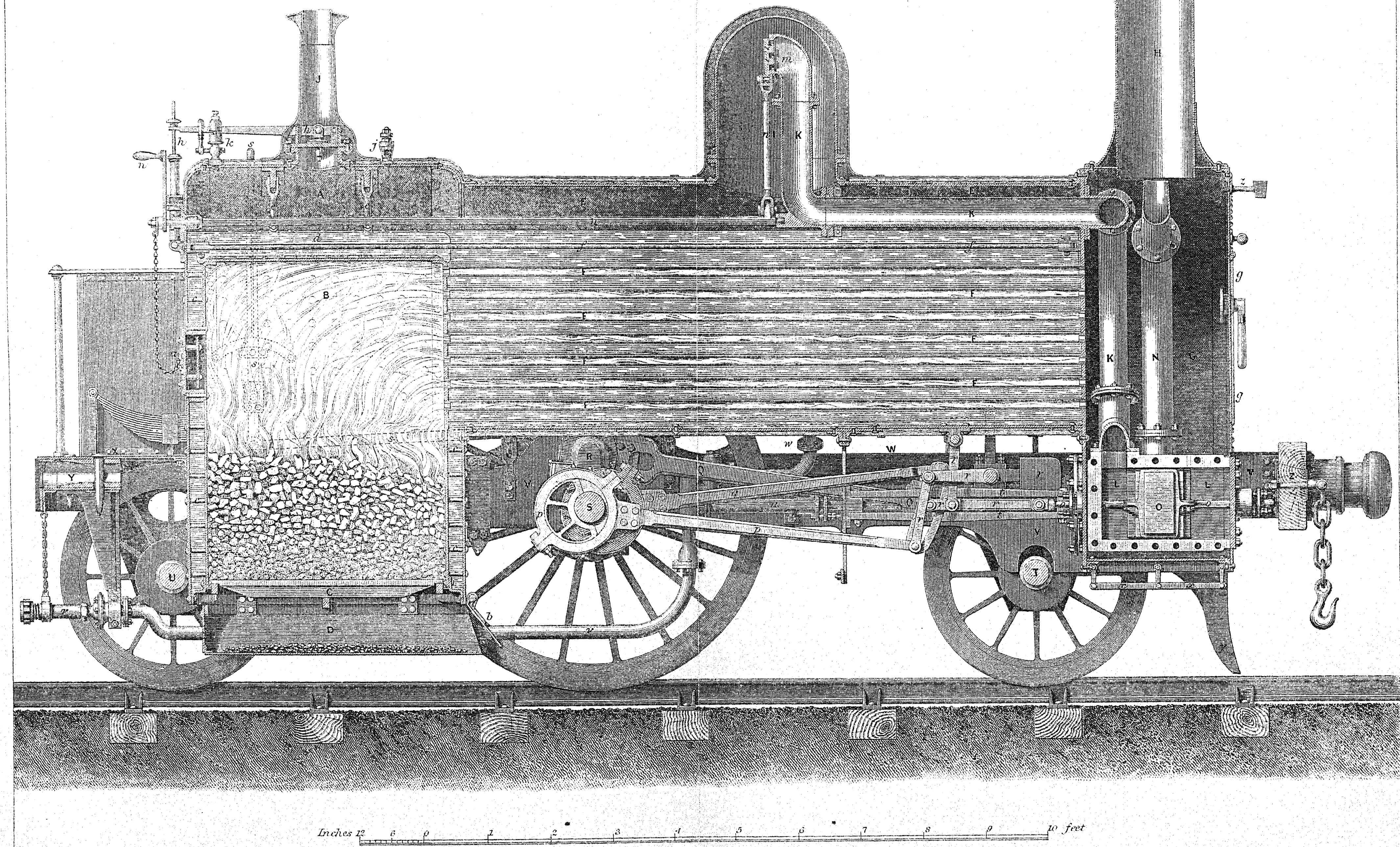
Fig. 3.



characterized respectively by their calorific and luminous effects. All rays are now known to have chemical effects on suitable substances, including those called heat-rays (as from a dish of boiling water), which are quite invisible.

LOCOMOTIVE ENGINE.

LONGITUDINAL SECTION TO ILLUSTRATE TERMS APPLIED TO THE VARIOUS PARTS.



Drawn by David Kirkaldy. Engraved by J. W. Lowry.

A Fire-box shell.
B Internal Fire-box.
C Grate or Fire-bars.
D Ash-pan.
E Cylindrical part of Boiler.
F Flue-tubes.
G Smoke-box.
H Chimney.
I Steam-dome.
J Steam-chimney.
K Steam-pipe.
L Valve-chest of Cylinder.
N Exhaust and Blast Pipe.
O Slide-valve.
Q Connecting-rod.
R Driving-crank.
S Driving or Crank Axle.
T Fore-axle.
U Hind-axle.
V Inside Framing.
W Outside Framing.
X Foot-plate.
Y Draw-plates.
Z Buffer-beam.
a Fire-door
b Draught-regulator.
c-f Stays.
g Smoke-box door with closing handle.
h Safety-valve.
j Water-heating Cock.
k Steam-whistle.
m Steam-regulator Valve.
n Gear for working regulator valve.
o Steam Valve-rod.
p,q Eccentrics and rods.
r Valve-link and working gear.
s Reversing-handle and gear.
t Piston-rod Guides.
u Feed-pump and Plunger.
v,w Feed-pipes.
x Water-cocks.
y Safety-guard for clearing rail.
z Bracket for signal-lamp.

When the beam of white light falls upon a given point, before being decomposed by the prism, these different kinds of effects are united, and the spot of white light will produce heat, light, and chemical effects, for the different waves are all mixed up and act together; but passing the beam through the prism, each of the simple rays of which the compound ray is formed will be bent in a different angle, and can be studied from the three points of light, heat, and chemical activity. The spectrum is therefore to the eye what the musical scale is to the ear, the several colours denoting notes of different pitch and waves of different lengths and rapidity of vibration, in which the red will be found on the left and the violet ray on the right of the visible spectrum. Fig. 3, in which the bottom represents the least and the top the most refrangible rays, gives by the curves the comparative luminosity, heating, and chemical power, of the different parts of the solar spectrum, the greatest intensity of light being found in the yellow.

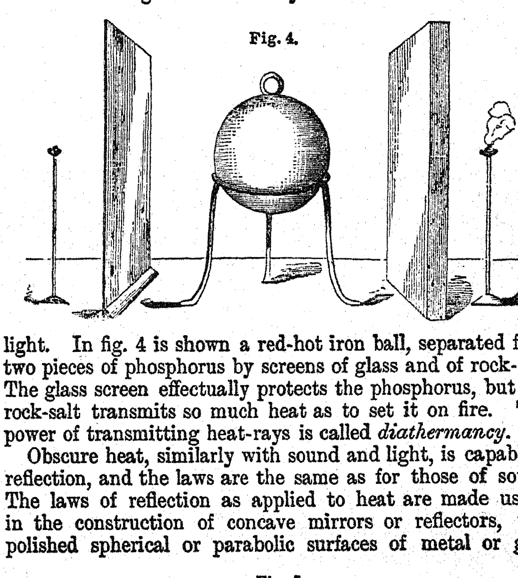
The length of the waves both of sound and light have been accurately determined, and likewise the rapidity of the vibrations or number of shocks that they respectively impart to the eye and ear; and it is found that the vibrations which produce the red ray at one end of the visible spectrum are slower and the wave-length longer than those which produce the violet at the other end, and that the other colours are produced by waves of intermediate length and velocity of vibration. Light travels with a velocity of about 192,000 miles in a second, or 12,165,120,000 inches, and it is ascertained that 39,000 waves of red light placed end to end are necessary to make one inch in length; consequently, in the distance of 192,000 miles, the number of red waves entering the eye in a second will be 12,165,120,000 × 39,000, or 174,439,680,000,000 waves; and to produce the impression of violet upon the brain the retina of the eye must receive a far greater number of vibrations in the second, as 57,500 waves of violet are necessary to fill the space of one inch. As with the ear, in which the sensation of sound is limited, the brain being unable to translate into sound vibrations beyond certain limits, so with the eye the brain fails to translate into light vibrations of ether exceeding certain limits; and therefore both beyond the red ray and the violet ray are *dark rays* invisible to the eye. For if the heating properties of the spectrum be examined by a *thermopile* or sensitive thermometer the maximum heating effect will be found a good deal beyond the red, in the dark rays invisible to the eye; in the same way heating power may be detected in the invisible rays beyond the violet, although of extremely feeble action; and in that portion of the spectrum commencing about the region of the blue and increasing towards the extreme end of the violet, and continued beyond the visible portion in both directions, are the chemical rays, which can be photographed by means of suitable chemicals, and thus rendered indirectly visible through their effects. The solar spectrum therefore appears to be formed of three parts, which are superposed so that one more or less overlaps the other. These invisible rays beyond the limits of the spectrum are called the *Herschelian* rays, from Sir William Herschel, who first discovered their existence. Seebeck also observed that when prisms of other material than rock salt are used, the position of maximum heat will be found to vary with the nature of the prism. The maximum heat will be found in the yellow with a prism of water, with one of crown glass in the middle of the red, the various prisms absorbing the rays of different refrangibility unequally.* A selective absorption both for light and heat is exercised by solid and liquid bodies; certain rays are selected to be absorbed and cut off, while others are transmitted. On examining the spectra of other luminous solid bodies they will be found analogous to that of the sun, with the exception of certain dark lines which cross the solar spectrum at right angles. When the temperature of the luminous body is not very high, the spectrum indicates considerable dark heat and luminosity, but only a small amount of chemical action; and as the temperature is lowered, both the amount of light and chemical action fall off, and when below a red heat both have entirely ceased, and the whole consists of dark heat on that part of the spectrum to the left of the red ray. Radiant heat may therefore be divided into two kinds, the one consisting of those invisible rays separated by the prism from light which lie to the left of the visible rays in the spectrum, and the second the heating effect which accompanies light and which is not separated from it by the prism. By examination of the properties of dark radiant heat and the luminous rays, the analogy between heat and light can be experimentally proved.

* Melloni discovered that rock salt has the property of transmitting radiant heat freely, and thus gives a normal spectrum.

There are, besides the prism, other methods of decomposing light. Some bodies are more transparent to one kind of light than another, and are termed *coloured media.* They absorb certain rays and transmit others. Thus, a thin stratum of a solution of bichromate of potash absorbs the best part of the green and all the blue, indigo, and violet rays, leaving the remainder of the light, the red, orange, yellow, and a portion of the green rays, visible; and if these rays are then passed through a second stratum of the same medium, they suffer but very little diminution in intensity, as the light absorbed by the first passage through the medium has already been removed, and that which is transmitted can pass most readily through the second.

When the second medium is of such a nature as to absorb most of the rays which the first transmits, nearly the whole of the light is cut off, although the second medium may itself be transparent for other rays already cut off by the first. The discovery by Melloni that different substances absorb different kinds of radiant heat, and that most substances which are transparent to light are the reverse with regard to heat, and also that the heat which radiates from a hot body when sifted by a screen of any substance will penetrate in greater proportion through a screen of the same substance, illustrates the general similarity between radiant heat and

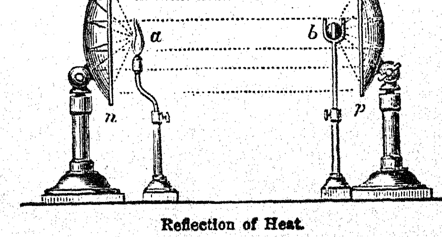
Fig. 4.



light. In fig. 4 is shown a red-hot iron ball, separated from two pieces of phosphorus by screens of glass and of rock-salt. The glass screen effectually protects the phosphorus, but the rock-salt transmits so much heat as to set it on fire. This power of transmitting heat-rays is called *diathermancy.*

Obscure heat, similarly with sound and light, is capable of reflection, and the laws are the same as for those of sound. The laws of reflection as applied to heat are made use of in the construction of concave mirrors or reflectors, with polished spherical or parabolic surfaces of metal or glass

Fig. 5.



Reflection of Heat.

to concentrate the luminous or heating rays in the same focus. In applying the laws of reflection from plane surfaces to spherical mirrors they are considered to be made up

of an infinite number of minute plane surfaces, the normals (or perpendiculars) to which are all radii of the same sphere, and therefore meet in its centre, which is also the centre of curvature of the mirror. If two mirrors are arranged so as to stand exactly opposite to each other (fig. 5), with their principal axis in the same line, as the property of the parabolic form of reflector is that rays of heat or light emanating from the focus, *a*, of one mirror are reflected in parallel lines, these rays, falling upon the other reflector, are again collected in its focus, *b*. By this arrangement the degrees of heat radiated from different bodies placed in the focus of one reflector can be estimated by placing the bulb of a thermometer in the focus of the other. For instance, a hot ball, *b*, placed in the focus of one reflector will considerably affect a thermometer placed in the focus of the other, and even inflame a piece of phosphorus at *a* in the figure. To show that the effect is not produced by the mere proximity of the heated ball to the thermometer, independent of actual reflection, remove the reflector having the thermometer in its focus, or cover it with a sheet of pasteboard: the thermometer will immediately indicate the absence of the quantity of heat it before received by falling rapidly, notwithstanding that the source of heat is as near the bulb as before. The same diminution of heat will likewise be indicated by the thermometer if it be removed from the focus of the reflector and placed nearer the heated body.

Heat, like light, may be reflected from rough surfaces, such as sandstone, white blotting paper, &c.; but the light and heat are diffused irregularly, for the surface of the sandstone, instead of being a plane upon which all the incident rays from a given source are striking at angles with no other difference than is due to the distance from each other, is a complex aggregation of a multitude of little planes standing out at all the angles possible within the arc of a semicircle, and the heat-rays coming from any given object strike different parts of this surface at all these various angles, and become scattered accordingly, while each individual ray obeys the law of reflection in reference to that portion of the surface upon which it is incident.

If a piece of ice is placed in one of the foci of the mirrors in place of the red-hot ball, the surrounding temperature being greater than zero, the thermometer in the focus of the other reflector will exhibit a decrease in temperature of several degrees; this is, however, not the effect of the remission of cold rays by the ice; there is an *interchange* of heat between the ice and the thermometer, but the thermometer is the warmest body, and the rays which it emits are more intense than those emitted by the ice, so that it gives out more heat than it receives, and hence its temperature falls. The sensation of cold that a person experiences when standing near a stone wall or other substance whose temperature is lower than the body arises from the same cause. By this "law of exchanges" all objects in the universe tend constantly toward one uniform temperature.

Leslie, who made various experiments upon the reflecting power of various substances for dark heat, has determined the reflecting powers of the following substances, calling that of brass 100, that is, the number of rays which it reflects out of every hundred which fall upon it, as well as the comparative reflecting power:

Polished brass, . .	100	Indian Ink, . . .	13
Silver, ...	90	Amalgamated tin, .	10
Tin, ...	80	Glass, ...	10
Steel, ...	70	Oiled glass, . . .	5
Lead, ...	60	Lampblack, . . .	0

Their absolute reflecting power is the relation of the quantity of heat reflected to the quantity of heat received. The following results were obtained by Desaius and De la Provostaye when the heat was reflected at an angle of 50°:—

Silver plate, . .	0·97	Steel, ...	0·82
Gold, ...	0·95	Zinc, ...	0·81
Brass, ...	0·93	Iron, ...	0·77
Platinum, . . .	0·83	Cast-iron, . . .	0·74

So that metals which reflect light most readily are also the best reflectors of dark heat. M. Jamin has also shown that when only a certain small portion of the spectrum is taken, the reflecting power of any body as regards the light of this portion is as nearly as possible the same as its reflecting power for the heat, or the heat which belongs to the light is reflected in the same manner as the light.

Metal employed.	Green rays, Reflecting power.		Red rays, Reflecting power.	
	Heat.	Light.	Heat.	Light.
Platinum, ...	59	—	60	—
Zinc, ...	65	62	60	58
Silvering of mirrors, . .	58	62	65	69
Brass, ...	63	62	75	72

The reflecting power of glass for heat increases very rapidly with the angle of incidence, and the law which regulates this increase is the same as that for light. The reflecting power of metallic surfaces for heat varies very slowly with the incident angle, a property which metals also possess with regard to the reflection of light.

From the numerous experiments made on the reflection of heat the following results have been established:—

Obscure heat is reflected, in the same way as light, very readily by metals.

Heat, whether reflected from the surface of glass or metal is subject to the same laws as light, the intensity of the reflected beam varying with the angle of incidence.

Heat, like light, is susceptible of a diffuse reflection from the surface of bodies.

The heat from a part only of the spectrum is reflected from a surface in the same manner as the light from that portion of the spectrum. From these conclusions it appears that the reflection of obscure heat is in conformity with the laws of the reflection of light, and that the illuminating and heating effects of any portion of the visible spectrum are caused by the same rays.

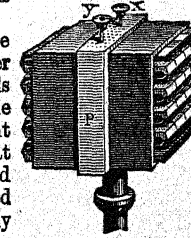
REFRACTION OF HEAT.

Melloni, by employing a rock-salt prism and a thermopile capable of detecting the presence of an exceedingly small amount of radiant heat, was the first to demonstrate experimentally that the heat which is radiated from a non-luminous source is capable of refraction, and Forbes obtained the following indices of refraction from rock salt:—

	Indices of Refraction.
Mean luminous rays, ...	1·602
Heat from Locatelli lamp, ...	1·571
Heat from incandescent platinum, . . .	1·572
Heat from brass at 371° C., ...	1·568

Sir W. Herschel, who first observed the dark rays beyond the red of the visible spectrum, propounded the theory of the refraction of heat, and the researches of Forbes also point out that dark rays of a less refrangibility than light belong to sources of heat of low temperature as well as of high temperature, such as the sun, the conclusion being that both as regards refrangibility and wave-length the dark portions of the spectrum are only appropriate prolongations of the luminous spectrum.

Fig. 6.



The *absorbing power* of a substance is its property of allowing a greater or less amount of the heat which falls upon it to pass into its mass, and the *absolute value* is the ratio of the amount of heat absorbed to the amount of heat received. A substance which is a good absorbent is always a bad reflector, and the absorbing power is consequently inversely as its reflecting power. The heat received by a body may be divided into three portions—that which is absorbed, that which is reflected, and that which is diffused. Consequently the sum of the reflected and absorbed heat is always less than the quantity of direct heat. Melloni experimentally determined the relative absorbing

power of various bodies, taking as a source of heat a canister filled with water at 100° C., and using a thermo-electric pile. This instrument (fig. 6) consists of a number of small bars of bismuth and antimony soldered together alternately, and at the same time insulated from each other, and contained in a rectangular box P. The terminal bars are connected with the binding screws X, Y.

Lampblack, . .	100	Indian ink, . .	85
White lead, . .	100	Shell-lac, . . .	72
Isinglass, . . .	91	Various metals, .	13

Delaroche has also shown that substances exercise a selective absorption for dark rays, or, as it were, sift a stream of dark heat transmitted through them, from which he considered that dark heat consists of different kinds of rays mingled together, in the same way that white light consists of a mixture of different coloured rays; and this view has been confirmed by the experiments of Melloni. But beyond ascertaining that there are different kinds of dark heat, how they are distributed in the spectrum is not at present known. Tyndall has likewise ascertained the absorptive powers of various gases for dark heat, from which it appears that the absorptive power of the three simple gases—air, oxygen, and nitrogen — and hydrogen are exceedingly small, and that where aqueous vapour is present in the atmosphere on a day of average humidity, its absorptive power is over sixty times that of the air itself. The following table gives the results of Tyndall's investigations:—

COMPARATIVE ABSORPTION OF VARIOUS GASES—Pressure 1 inch.

Air, ...	1	Carbonic oxide, . .	750
Oxygen, ...	1	Nitric oxide, . .	1590
Nitrogen, ...	1	Nitrous oxide, . .	1860
Hydrogen, . . .	1	Sulphide of hydrogen,	2100
Chlorine, ...	60	Ammonia, . . .	7260
Bromine, ...	160	Olefiant gas, . . .	7950
Hydrobromic acid, .	1005	Sulphurous acid, .	8800

From these results Tyndall deduces that the absorption of the simple gases is much less than that of the compound ones. Tyndall has likewise shown that the absorptive power of scents for dark heat is very great, as also that of ozone.

A coloured body, such as red glass, absorbs one kind of light more than another; but even when bodies are apparently of the same colour, their power of absorbing certain rays of light may greatly vary, and may have a very different selective absorption for certain rays. Port wine and blood are two liquids of somewhat similar colour; but if a spectrum be thrown upon a screen painted with blood, dark bands will be seen in the yellow and green, while port wine will absorb the more refrangible rays of the spectrum.

The capability of a substance for emitting greater or less quantities of heat at the same temperature, is its *radiating* or *emissive* power. Leslie, by applying Newton's law and taking lampblack as 100, ascertained the relative radiating powers of certain substances as follows:—

Lampblack, . . .	100	Plumbago, ...	75
White lead, . . .	100	Tarnished lead, . .	45
Paper, ...	98	Mercury, ...	20
Sealing wax, . . .	95	Polished lead, . . .	19
Ordinary glass, . .	90	Polished iron, . . .	15
Indian ink, . . .	88	Gold, ...	12
Isinglass, ...	80	Copper, silver, &c., .	12

—the radiating power being exactly the reverse of their reflective power. From the experiments by Desaius and De la Provostaye, the results obtained by Leslie appear to be too high for metals, as the following table shows:—

Lampblack, . . .	100	Gold leaf, ...	4·28
Platinum foil, . . .	10·80	Silver laminated, . .	3·00
Burnished platinum, .	9·50	Silver burnished, . .	2·50
Silver (deposited), . .	5·36	Silver deposited and burnished, . . .	2·25
Copper foil, ...	4·90		

Dulong and Petit have demonstrated the identity of the absorbing and radiating powers of bodies, and that the mutual relation of the absorbing and radiating powers are exactly proportional to each other. A large differential thermometer is constructed, having the glass bulbs replaced by cubical vessels, A and B, of equal size, and so arranged that the two surfaces opposite to each other shall be exactly parallel. Of these one, A, is polished, and the other, B, is coated with lampblack. Midway between them is placed a similar vessel, C, having one of its faces highly polished, and the opposite one coated, as before, with lampblack. This vessel is placed on a vertical axis, so that any of its plane surfaces may be placed parallel to the interior plane surfaces of the vessels answering to the bulbs of the thermometer: thus, its coated surface can be placed opposite to the polished surface of the bulb, as supposed to be shown in fig. 7, or

Fig. 7.

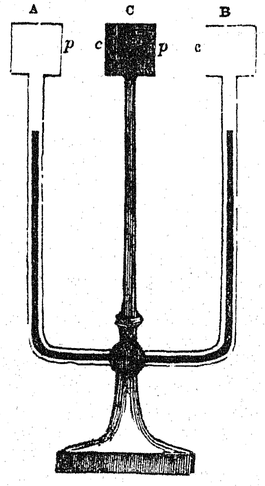
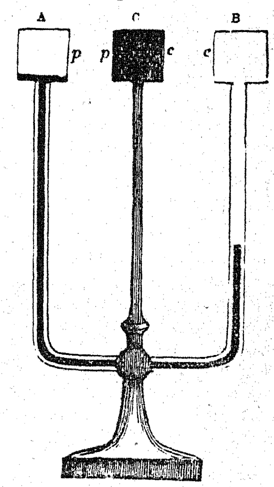
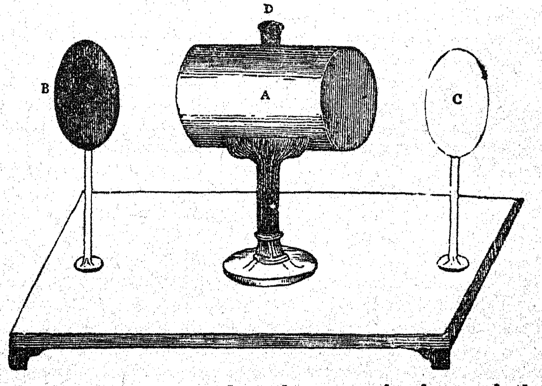


Fig. 8



opposite the coated surface of the bulb, as represented in fig. 8. When a hot liquid, as oil, is poured into the intermediate vessel, when the apparatus is arranged as in fig. 7, no effect on the thermometer is perceived, for the respective actions of the surfaces exactly balance one another; the better radiating surface is directed to the worse absorbing one, and the worst radiating to the better absorbing; and radiation and absorption being equal, the liquid in the tube of the thermometer remains perfectly stationary. To prove that this is the true explanation, it is only necessary to turn round the vessel to the position shown in fig. 8. Where like surfaces are opposite each other, that is, metal to metal and black to black, an immediate effect is perceived. In this case the

Fig. 9.



worse radiator is opposed to the worse absorber, and the good radiator to the good absorber, and consequently everything is favourable to the effect on the one side and opposed to it on the other; the liquid of course ascends in the stem of A and descends in the stem of B.

There is another form of this experiment (fig. 9) which shows very decisively the relation between radiation and absorption. The apparatus consists of a cylindrical tin vessel, A, which

can be filled with hot water through the opening, D. Equidistant on either side are placed two metal discs, B, C—the one coated with lampblack, the other either painted white or covered with silver foil. The end of the cylinder A facing B is painted white, and that facing C black, so that the two faces opposed to each other are black and white. When the cylinder A is filled with hot water its white face radiates towards the blackened face of B, and its black face towards the white face of C. It will be found that the greater emissive power of the blackened end of A is compensated by the less absorptive power of the white disc C, and the smaller radiating power of the white face of A is compensated by the larger absorbing power of the black disc B.

FORMATION OF DEW.

The atmosphere, while it stops a comparatively small portion of the solar rays in their progress to the earth, arrests a very large portion of those which are given out from the surface of the earth; and from the known presence of aqueous vapour in the atmosphere, while it absorbs most of the dark heat from the surface of the earth, permits the passage of the solar rays with comparative freedom, so that during the night the absorptive nature of the atmosphere for dark heat reduces the rate of cooling of the earth most materially.

The climatic influences that arise from the absence of vapour in the atmosphere have already been alluded to, and the extreme cold at night that succeeds to the sultry heat of the day.

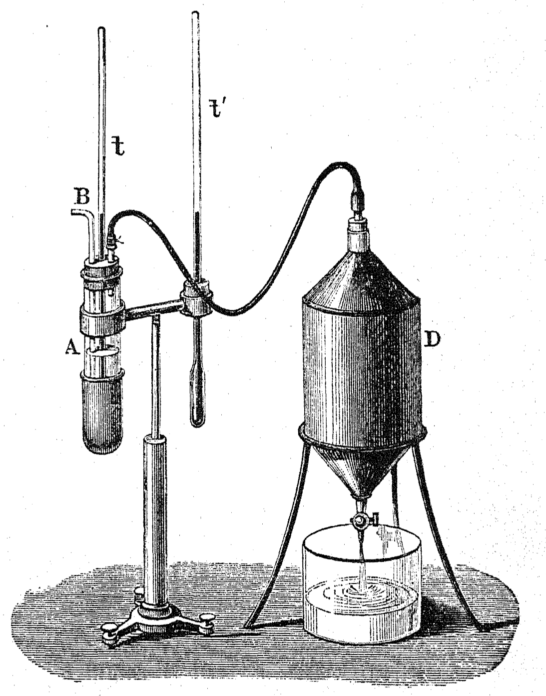
The formation of dew was investigated by Dr. Wells of London in 1818, and by experiment he ascertained that the formation of dew was most plentiful when the sky was clear and the atmosphere calm, and that the deposit of dew was most copious on those substances exposed to the sky, and on bodies which are good radiators of heat and placed near to the surface of the ground.

The formation of dew is always accompanied with a lowering of temperature, and is most plentiful where the temperature sinks lowest. As the formation of dew is the result of radiation, a solid substance which is a good radiator and is exposed to a clear sky will lose a large portion of its heat by uncompensated radiation into space, and is thus reduced in temperature below that of the surrounding air; and as the particles of air in contact with this colder substance also part with their heat when they reach a temperature at which they can no longer retain their aqueous vapour, it is deposited upon the solid body. In the case of a body above the earth the fall of dew is less, as the formation of dew is the effect of cooling by radiation. When the air in contact with the body becomes cooler it also becomes heavier, and sinks down to the surface, its place being supplied by lighter and warmer air, so that the cooling is not sufficiently intense to produce dew in any quantity. Various forms of condensing hygrometers have been devised to register the dew point.

Regnault's hygrometer (fig. 10) consists of a very thin polished silver thimble, 1·75 inch in height, and 0·75 inch in diameter; in this is fixed the glass tube A, and the thermometer *t*. A bent tube B, open at both ends, passes through the cork of the tube A, and reaches nearly to the bottom of the thimble. The brass support for the tube carries a thermometer *t′* for indicating the temperature of the atmosphere. The glass tube A is connected by means of a tube with the aspirator D. The tube A is half filled with ether, and when the stop-cock of the aspirator is opened the water it contains runs out, and the equivalent of air enters through the tube B, and bubbling through the ether causes it to evaporate. This evaporation produces a reduction of temperature, so that dew is deposited on the silver. The thermometer *t* is immediately read off, and the flow from the aspirator stopped. The dew soon disappears, and the thermometer *t* is again read, when the mean of the two readings is taken as the dew point; the thermometer *t′* gives the temperature of the air.

Daniell's hygrometer (fig. 11) consists of two glass bulbs, *a* and *b*, at the ends of a glass tube twice bent. The bulb *a*, which contains a very delicate thermometer *t*, is two-thirds filled with ether, the rest of the space only containing the vapour of ether, obtained by boiling the ether before the bulb *b* was sealed. The bulb *b* is covered with muslin, and ether dropped upon it. The ether, evaporating, cools the bulb, and the vapour contained in it is condensed. The internal tension being thus diminished, the ether in *a* forms vapour which condenses in the bulb *b*, and in proportion as the liquid distils

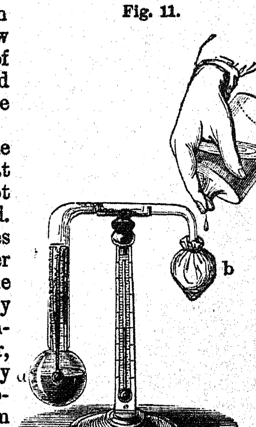
Fig. 10.



Regnault's Hygrometer.

from the bulb *a* into *b* the ether in *a* becomes cooler, and eventually the temperature of the air in contact with *a* sinks to that point at which its vapour is more than sufficient to saturate it, and it becomes deposited on the outside as a ring of dew corresponding to the surface of the ether. The addition of ether to the bulb *b* is then suspended, the temperature of *a* rises, and the temperature at which the dew disappears noted. These two points being noted their mean is taken as that of the dew point. The temperature of the air at the time is indicated by the thermometer on the stem of the apparatus.

Fig. 11.



Daniell's Hygrometer.

It is upon the principle of the deposit of dew that the formation of ice in hot climates may be explained. In Calcutta and other places shallow pans containing water are exposed at night to the clear sky, and are frequently covered with ice in the morning. Tyndall has, however, shown that to produce ice by radiation in this way an absence of aqueous vapour from the air is necessary, and those nights most favourable for its production are those which are clear and calm, and in which very little dew falls after midnight. Hoar-frost and rime are simply dew which, having been deposited upon bodies cooled below zero, has become frozen. Hoar-frost is formed upon bodies which radiate most freely, such as the stalks and leaves of vegetables and plants, and is mostly deposited upon those parts turned towards the sky.

CHAPTER XIX.—HEAT.

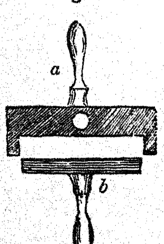
EXPANSION OF SOLIDS—OF METALS—FORCE OF CONTRACTION OF SOLIDS—COMPENSATION BALANCE AND PENDULUM—ALLOWANCE FOR EXPANSION AND CONTRACTION OF METALS—CUBICAL EXPANSION OF SOLIDS—EXPANSION OF FLUIDS—ABSOLUTE EXPANSION—OF MERCURY—OF LIQUIDS—EXPANSIVE FORCE OF LIQUIDS—CRYSTALLIZATION—FORMATION OF ICE—REGELATION—FUSION—MELTING POINT—FLUXES—SOLUTION—FREEZING MIXTURES—APPARATUS FOR FREEZING MEATS—ICE-MAKING MACHINE—CHEMICAL FOOT-WARMERS—NON-CONDUCTORS OF HEAT—VAPOUR IN VACUO—NON-SATURATED VAPOURS—TENSION OF AQUEOUS VAPOURS.

ALTERATION OF VOLUME IN SOLIDS, LIQUIDS, AND GASES.

THE most general and remarkable effect produced upon bodies by the absorption and the emission of heat is alteration of volume. All bodies in nature—solids, liquids, and gases—are increased in dimension when heat is absorbed by them, and contract again to their former volume when they regain their former temperature. The particles of matter are held together by cohesion, acting strongly in solids and slightly in liquids, and the body exists in a gaseous state when the cohesive force is removed. These gradations of the force of cohesion regulate the state of a body, and any force which is capable of counteracting it must at the same time be capable of altering the relative distances of the constituent particles from one another. This is what heat effects—it is the repulsive principle which nature has set up to operate as the antagonist of cohesion; it removes the molecules of matter further asunder, making them occupy more space, and the consequence is an increase of the general volume.

In solids, the force of cohesion being great, the expansion is comparatively small; in liquids, where it is less, the expansion is much more considerable, and in aëriform substances, where the cohesive force is least, the expansion is by far the greatest. The way in which a solid expands varies according as the substance is crystalline in its structure or amorphous. In some cases it is the increment of the volume of a body that has to be observed; in others, such as a bar of metal, it is change of length that has to be measured. The former of these is termed *cubical*, and the latter *linear* expansion. The *coefficient of expansion* of a substance, whether linear or cubical, is the *expansion for one degree of temperature of that quantity of the substance whose length or volume was unity at a certain standard temperature* (0° C.) If the length of a brass rod be unity at 0° C. it will be 1·00001890 at 1° C., hence 00001890 is the linear coefficient of expansion of brass for 1° C. The expansion of solids may be illustrated by the circumstance that a lead bullet, which at the ordinary temperature of the atmosphere just passes freely into the barrel of a gun, cannot be forced in without great exertion while at a temperature of boiling water. The same experiment may be made by fitting a metallic rod with a ring just large enough to move freely when the rod is cold; when the rod is hot it will not pass through the ring. A brass rod, *b* (fig. 12), is of such length that when cold it just enters lengthwise between the projections at the end of a flat iron piece, *a*, and by its ends passes into the round hole. When the piece *b* is heated it is found to be too long to pass between the projections, and too thick to enter the hole; as it cools it resumes gradually its original dimensions, and will ultimately fit as before. Were the bar and the gauge both of the same metal, iron, if they were made to fit when cold they would fit at all equal temperatures, for the one would expand as much as the other; but here the bar is supposed to be brass and the gauge iron, and it is found that when both are made red-hot the parts of the apparatus do not fit, for although both metals expand, they expand differently, and the brass more than the iron.

Fig. 12.



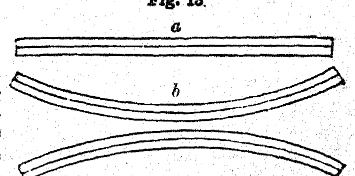
The following table gives the coefficients of linear expansion of various substances:—

Substance.	Length of a rod at 100° C. whose length at 0° C.=1·000000.
Pine,	0·000006080
Graphite,	0·000007860
Marble,	0·000008490
Flint glass,	0·000008613
Platinum,	0·000008862
Tempered steel,	0·000012395
Untempered steel,	0·000010788
Cast iron,	0·000011250
Wrought iron,	0·000012204
Sandstone,	0·000011740
Gold,	0·000014660
Copper,	0·000017182
Bronze,	0·000018167
Brass,	0·000018780
Silver,	0·000019097
Tin, East Indian,	0·000019380
" English,	0·000021730
Lead,	0·000028575
Zinc,	0·000029417
Sulphur,	0·000064130
Ebonite,	0·000084200
Paraffin,	0·000278540

The coefficients of *cubical* expansion of solids are obtained by *multiplying those of linear expansion by three.* Metals vary in the coefficients of their expansion with their physical condition, whether hammered and rolled or hardened and annealed; generally increase of density increases the rate of expansion. Compound substances, as glass, brass, or steel, from a want of uniformity in their chemical composition, vary considerably in their amounts of expansion. Lead, on account of its softness and viscosity, does not contract to its original dimensions after expansion. Thus, a lead-covered roof exposed to the full heat of the sun becomes permanently buckled, and lead pipes conveying steam become permanently elongated. In ordinary cases the force of contraction in cooling is very great, and has been frequently applied to restore bulged walls to their proper position by passing an iron bar across the building with screwed ends projecting through the walls. On heating the bar it lengthens, and while hot the buttress plates are screwed up close to the outside of the walls by means of nuts on the screw ends of the bar. On cooling the bar contracts, drawing the walls with it. The walls of the Conservatoire des Arts et Métiers, Paris, and those of the Cathedral of Armagh, which had yielded to the pressure of the roof, were by this process restored to the perpendicular. The clamping together the felloes of a cart-wheel by means of an iron tire fitted on while red-hot, is another example of the force of contraction.

Iodide of silver is an exception to the general law that all bodies expand by heat, as it contracts slightly when heated, and has a *negative* coefficient of expansion, the value of which is 0·00000139 for 1° C.

Fig. 13.



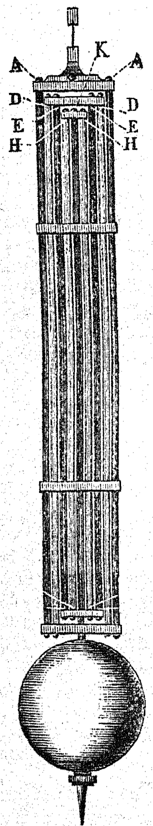
The unequal expansion of different solids is shown by riveting together thin strips of steel and brass, or copper and platinum. At the temperature of the bars, when put together, the compound bar will be straight, as in fig. 13, *a*; but the brass being more *expansive* than steel, it will assume the form shown in *b* when exposed to a higher temperature, and the brass being likewise more *contractive* than the steel, it will take the form shown at *c* at all inferior temperatures.

There are some mechanical operations in which it is necessary to determine the amount of expansion and contraction of the metals employed with the utmost degree of accuracy. This is particularly the case with astronomical

instruments and instruments employed in laying down the base line of a trigonometrical survey, where the error of an inch in a mile would be fatal. The same accuracy must be attended to in regulating the rate of going of a clock. When the length of the seconds pendulum is increased only the hundredth part of an inch, the clock loses ten seconds in twenty-four hours; and a change of temperature of only 30 degrees, if the pendulum be of the common sort, with an iron stem, will occasion an error in the rate of going of eight seconds a day. Variations of temperature also occasion variations in the oscillations of the balance-wheels of watches. These effects are obviated by various compensating apparatus, depending upon an accurate comparison of the different expansibilities of the metals employed.

The compensating balance-wheels of chronometers and watches are made of two segments, nearly halves of a circle, formed of steel inside and of brass outside, and so adjusted that the expansion of the whole circle is corrected by the closing curvature of the two segments. The compensating pendulum is likewise constructed on a similar principle. Thus in the gridiron pendulum, shown in fig. 14, the relative lengths of the steel rods A, E, K, which lengthen downwards, and the brass rods D, H, which lengthen upwards by their expansion, are made inversely as the different expansibility of their constituent metal, so that they must compensate each other. Saucepans and other culinary vessels lined with glassy enamel, although very cleanly, cannot be freely used on account of the cracking and chipping away of the enamel, which is due to the greater expansion of the metal when heated. When metals are employed on a large scale, the expansion and contraction become of practical and important magnitude. For instance, the central arch of Southwark Bridge, an iron structure, rises over 1 inch in summer, lifting with it the footpath and roadway, and unless this movement was compensated the stability of the entire structure would be endangered. To compensate the expansion and contraction of the Britannia Bridge, Menai Straits, the ends rest on friction rollers, upon which they advance and retire as the tube elongates and contracts. Sliding joints are necessary for hot-water pipes, and if allowance was not made for the expansion and contraction of the rails on a railway the line would be dangerously contorted, or the rails displaced, by the expansion due to summer heat.

Fig. 14.



The cubical expansion of a solid may be determined by either weighing the substance at different temperatures in a liquid of which the absolute expansion is known, or by inclosing the substance in a glass vessel, the remainder of which is filled with mercury or water. If the absolute expansion of either of these liquids is known, that of the glass envelope and of the inclosed solid may be determined.

From the tables that follow it will be seen that different bodies expand more or less under the influence of heat. Some bodies, however, as crystals, expand unequally in the direction of their different axes, thus altering the magnitude of their angles as well as their shape. Thus double refracting crystals expand more in the direction of their optic axis than at right angles to it. Mitscherlich, who investigated this subject at great length, concludes that the tendency of heat in crystals is to augment the mutual distance of the molecules in that direction in which this distance is least, so as to equalize the distance in different directions and bring the axes into a state of equality.

The following table of cubical expansion of metals gives the results of very valuable experiments by Dr. Matthiesen:—

Metal, &c.	Coefficient of expansion for 1° C. between 0° C. and 100° C.
Cadmium,	·00009478
Zinc,	·00008928
Lead,	·00008399
Tin,	·00006889
Silver,	·00005831
Copper,	·00004998
Gold,	·00004411
Bismuth,	·00003948
Palladium,	·00003312
Antimony,	·00003167
Platinum,	·00002658
Glass,	·00002540
Iron,	·00003546

Comparing this last table with the preceding one of linear expansion, it will be seen that the cubical expansion is in every case about equal to three times the linear expansion of the same substance.

COMPARISON OF LINEAR AND CUBICAL EXPANSIONS.

Substance.	Mean Linear Expansion between 0° C. and 100° C.	Mean Cubical Expansion between 0° C. and 100° C.
Glass,	·000008613	·00002540
Copper,	·000017182	·00004998
Lead,	·000028575	·00008399
Tin,	·000019380	·00006889
Zinc,	·000029417	·00008928
Iron,	·000011250	·00003546

In fluids, as the cohesive force between the particles is very slight, their amount of expansion with a given increase of temperature is much greater than that of solids, and they differ in their variations of expansibility to a greater extent than solids. The rate of expansion of liquids is not uniformly proportionate to their increase of temperature; it increases as the temperature rises, and is subject to considerable variations as the boiling point is approached, and likewise as the temperature of solidification is reached.

In examining the expansion of liquids, allowance has to be made for the expansion of the containing vessel, hence the *apparent* expansion is less than the *absolute* expansion by the difference between that of the liquid and that of the containing vessel. This difference may be shown by fitting a small tube to the neck of a glass flask, and then filling the flask with water so that it rises a short distance up the tube. When the flask is suddenly plunged into boiling water the liquid in the tube appears to contract; this is due to the expansion of the glass flask, which takes place before the heat is communicated to the mass of water; as the water expands it rises in the tube. The apparent expansion of a liquid may be ascertained by using a glass vessel similar to a thermometer bulb, where the relative capacities of the bulb and given lengths of the tube are known. If the expansion of the glass vessel is accurately ascertained, the absolute expansion of the liquid can be determined. Mercury is taken as the standard of expansion for determining that of other liquids. Between the freezing and boiling points of water—

Mercury	expands	1	part	in 55.
Water	"	1	"	21.
Oil	"	1	"	12½.
Alcohol	"	1	"	9.

Thus alcohol is about two and a half times more expansible than water, and six times more expansible than mercury.

As the absolute expansion of a liquid is its apparent expansion plus the expansion of the containing vessel, the coefficient of the cubical expansion of glass is obtained by taking the difference between the coefficient of absolute expansion of mercury in glass and that of its apparent expansion.

The coefficient of the cubical expansion of glass is 0·002584. For ordinary chemical glass tubes it may be taken as 0·00254.

The apparent expansion of liquids between 0° C. and 100° C., as determined by Pierre and Kopp, are:—

1000 parts	Distilled water	become	1046	parts.
"	Saturated brine	"	1050	"
"	Hydrochloric acid	"	1060	"
"	Sulphurous acid	"	1060	"
"	Olive oil	"	1073	"
"	Oil of turpentine	"	1084	"
"	Bromine	"	1103	"
"	Acetic acid	"	1105	"
"	Nitric acid	"	1110	"
"	Alcohol	"	1110	"
"	Chloroform	"	1111	"
"	Bisulphide of carbon	"	1114	"
"	Benzine	"	1118	"
"	Ether	"	1148	"

Regnault has constructed a table giving the absolute expansion of mercury for every ten degrees centigrade from 0° C. to 350° C.

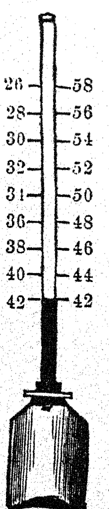
1,000,000 parts at 0° C. become

1001792	at 10° C.	1034922	at 190° C.
1003590	" 20	1036811	" 200
1005393	" 30	1038704	" 210
1007201	" 40	1040603	" 220
1009013	" 50	1042506	" 230
1010831	" 60	1044415	" 240
1012655	" 70	1046329	" 250
1014482	" 80	1048247	" 260
1016315	" 90	1050171	" 270
1018153	" 100	1052100	" 280
1019996	" 110	1054034	" 290
1021844	" 120	1055973	" 300
1023697	" 130	1057917	" 310
1025555	" 140	1059866	" 320
1027419	" 150	1061820	" 330
1029287	" 160	1063778	" 340
1031160	" 170	1065743	" 350
1033039	" 180		

By the above table it is found that equal increments of temperature produce continually increasing degrees of expansion of the mercury as the temperature rises.

The force which liquids exert in expanding is enormous, and equal to that which would be required in order to bring them back to their original volume. Between 0° C. and 10° C. mercury expands by 0·0015790 of its volume at 0° C. Its compressibility is 0·00000295 of its volume for one atmosphere, therefore a pressure of more than 600 atmospheres would be necessary to prevent mercury expanding when its temperature is raised from 0° C. to 10° C.

Fig. 15.



The determination of the expansion of water is a matter of considerable importance. When a flask and tube (fig. 15) are filled with water at the ordinary temperature (15° C.), and plunged into a vessel containing a freezing mixture of salt and broken ice, the water in the tube will at first fall rapidly, then more slowly, until it becomes stationary; it then rises again before the cooling of the water in the flask has been completed. When accurate means are taken to estimate the temperature of the liquid, it will be found to expand equally on both sides of 42° Fahr. (5·5° C.), that is, when cooled to 40° Fahr. (4·4° C.) it rises to the same point in the tube as when heated to 44° Fahr. (6·6° C.) At 32° Fahr. (0° C.) it stands at the same height as at 52° Fahr. (11·1° C.), and so on for different temperatures, as shown in the figure in Fahrenheit degrees. Water, therefore, expands as it cools down towards its freezing point, and in the act of freezing, when the experiment is carefully conducted, it will be found that this expansion commences at 4° C. or 39·2° Fahr., and continues down to the freezing point, when 100,000 parts become 100,013, or an increase of volume of about $\frac{1}{7692}$. This expansion is only a fraction of what takes place if the cooling is continued until the mass of the water is frozen; the original 100,000 volumes then become increased by 6·300 instead of only ·013. Thus water in passing from the liquid to the solid state suddenly augments in bulk about one-fifteenth without any alteration of temperature. The maximum contraction of water is therefore at 4° C. The force that this expansion exerts is stupendous; no ordinary vessel can resist its expansive force in freezing—water pipes are burst open and rocks are rent asunder. In this display of prodigious force there is another expansive agent besides heat. When water solidifies it assumes a different structure to that of wax or resinous substances, which become solid and retain nearly the same structure that they possessed when liquid. Water in becoming solid assumes a crystalline structure. A growth will be observed of angular stems, from which again angular branches diverge. When a thin film of water freezes this crystalline structure remains visible, as on a window; but in a thicker mass these stems and radial branches become so agglomerated that they cannot be distinguished separately, and it is this assumption of the crystalline structure that gives rise to the sudden expansion. Besides water there are some metals, as antimony and bismuth, that also assume a crystalline structure on solidification, and in a less degree expand at the same moment. This exceptional behaviour of water shows that expansion may be produced by something else besides heat, such as the assumption of crystalline structure and some unknown molecular condition which water assumes preparatory to its crystallization. The following table gives the volume of water at different temperatures, and shows that the increasing rate of expansion as the temperature rises is much greater in water than in mercury. Between 10° C. and 20° C. the expansion is only equal to 152 parts; between 90° C. and 100° C. it amounts to 749:—

VOLUME OF WATER AT DIFFERENT TEMPERATURES.

Temperature.	Volume.	Temperature.	Volume.
0° C. . . .	100013	50° C. . .	101205
4°. . . .	100000	60°. . .	101698
10°. . . .	100027	70°. . .	102255
20°. . . .	100179	80°. . .	102885
30°. . . .	100433	90°. . .	103566
40°. . . .	100773	100°. . .	104315

The large amount of the latent heat of water, combined with the fact that ice is lighter than water, are circumstances of great importance in the economy of nature. When a lake freezes, as the upper layer of water is cooled by contact with the cold air and from other causes, as radiation, it becomes heavier and sinks to the bottom, and the warmer and lighter water from below rises to the surface; thus a continual series of currents arise until the whole water of the lake is reduced to 4° C., the point of maximum density of water. When this temperature has been reached the interchange by currents ceases, and any further cooling of the upper strata will not cause them to sink, as they become specifically lighter below 4° C. On the surface of the lake being cooled down to 0° C. it will begin to freeze slowly, since a great quantity of heat must be taken from water before it becomes ice. As soon as a layer of ice is formed it remains on the surface, so that a second layer can only be frozen through the substance of the first, and so on. The ice thus formed protects the water below, which remains at 4° C. even in the most severe winters, a temperature which is not destructive to animal life.

Faraday was the first to observe a very curious property of ice, *regelation*, or the adhering together of two pieces of thawing ice. This adhesion takes place in air, in water, or in vacuo, and appears to be independent of the application of pressure, and if the surfaces are smooth and the two pieces are brought into the slightest contact regelation takes place. The same thing takes place in the formation of a snowball. Sea water freezes at a temperature below that of fresh water, producing a pure ice, and leaving the salt behind; thus the

Arctic Ocean is protected like fresh-water lakes by the surface ice.

FUSION.

When a body passes from the solid into the liquid state *melting* or *fusion* takes place, and when such bodies do not change their composition in the act of fusion the following laws invariably govern the act of melting:—

Every substance begins to melt at a certain temperature, which is constant for the same substance if the pressure be constant.

Whatever be the intensity of the heat applied, from the moment fusion commences the temperature of the body ceases to rise, and remains constant until the fusion is complete.

If a body expands in congelation its melting point is lowered by pressure, but if a substance contracts in congelation its melting point rises by pressure.

The following table gives the melting point of various bodies under ordinary atmospheric pressure:—

TABLE OF MELTING POINTS IN DEGREES CENTIGRADE.

Ice,	0·0°	Tin,	232·8°
Bromine,	12·5	Bismuth,	266·7
Butter,	33·0	Cadmium,	321·0
Oil of vitriol,	34·4	Lead,	326·7
Mercury,	38·8	Zinc,	360·0
Phosphorus,	44·2	Antimony,	432·0
Spermaceti,	49·0	Silver (pure),	1000·0
Potassium,	57·8	Copper,	1054·0
Stearine,	60·0	Gold (pure),	1250·0
White wax,	65·0	Wrought iron (Fr.),	1500·0
Stearic acid,	70·0	Wrought iron (Eng.),	1600·0
Sodium,	97·6	Platinum,	1775·0
Sulphur,	115·0	Iridium,	1950·0

Some bodies, such as glass and iron, have no defined melting point, but pass from the solid to the fluid state by imperceptible stages, becoming softer and softer when heated. This intermediate condition is termed the state of *vitreous fusion*.

Professor James Thomson, of Belfast, deduced from the principles of the mechanical theory of heat, that the melting point of a body would be raised with an increase of pressure. All bodies which expand on passing from the solid to the liquid state have external work to perform, in raising the weight of the atmosphere by the amount of their expansion, so that when the external pressure is increased the amount of external work to be performed is increased, and the temperature of fusion as well as the heat of fusion are both augmented.

Bunsen found that spermaceti, which melts at 48° C. under a pressure of one atmosphere, melted at 50·89 under a pressure of 156 atmospheres, and at a pressure of 519 atmospheres it melted at 60° C., while the melting point of sulphur under these pressures was 135° and 141° C. respectively.

Bodies which contract on passing from the solid to the liquid state, as water, have no external work to perform, and hence a less heat is necessary to liquefy them.

Sir William Thomson determined that pressures of 8·1 and 16·8 atmospheres reduced the melting point of ice by 0·059 and 0·126 respectively; and Mousson, by the application of the enormous pressure of 13,000 atmospheres, lowered the temperature of freezing water from 0° C. to −18° C.

Therefore an increase of n pressures of atmospheres lowers the melting point of ice by 0·0074 n° C.

ALLOYS AND FLUXES.

The fusing point of a mixture of bodies, such as *alloys* and *fluxes*, is generally considerably lower than that of either of its components. Thus, while tin fuses at 232·8° C. and lead at 326·7° C., an alloy of five parts of tin and one part of lead fuses at 194° C. Rose's fusible metal, consisting of four parts of bismuth, one part of lead, and one part of tin, fuses at 94° C., a temperature below that of boiling water. Wood's fusible metal, consisting of one part of cadmium, two parts of tin, four parts of lead, and eight parts of bismuth, melts between 66° and 71° C. Such alloys are of great use in soldering and in taking casts. Steel melts at a lower temperature than iron, although it contains carbon, which is practically infusible. Similar results take place on mixing salts together in the proportion of their chemical equivalents, such as the carbonates of potassium and sodium, and on this principle fluxes are added to an ore to promote the reduction of the substance to the metallic state.

SOLUTION.

Substances which change their composition in passing from the solid to the liquid state, in consequence of an affinity between their molecules and those of a liquid, are said to dissolve. Sugar, gum-arabic, and most salts dissolve in water, and the weight which can be dissolved usually increases with the temperature. A liquid is said to be saturated when it has dissolved as much as it can take up at a particular temperature.

During solution, as well as during fusion, a certain amount of heat always becomes latent, so that the solution of a substance generally produces a diminution of temperature; thus the temperature of soup is reduced by adding salt to it, and also that of tea by dissolving sugar. In certain cases, however, the temperature may rise, as when caustic potash is dissolved in water—the chemical combination with the water producing an increase of temperature.

This absorption of heat in the passage of bodies from the solid to the liquid state has been utilized to produce artificial cold. If two solids, or one liquid and one solid, are mixed together to produce a compound which is not solid but liquid, as water and a salt, ice and a salt, or an acid and a salt, cold is generally produced. Chemical affinity assists the fusion, and the portion which melts absorbs from the rest of the mixture a large amount of sensible heat, which becomes latent, and a very considerable diminution of temperature results. Freezing mixtures are formed upon this principle. The following table shows the reduction of temperature obtainable by some of them:—

	Parts by Weight.	Reduction in Temperature.
Nitrate of ammonia,	1	From 10° C. to −15° C.
Water,	1	
Sulphate of sodium,	8	" 10 to −17
Hydrochloric acid,	5	
Pounded ice or snow,	2	" 10 to −18
Common salt,	1	
Sulphate of sodium,	3	" 10 to −19
Dilute nitric acid,	2	
Sulphate of sodium,	6	" 10 to −26
Nitrate of ammonium,	5	
Dilute nitric acid,	4	
Phosphate of sodium,	9	" 10 to −29
Dilute nitric acid,	4	
Snow,	3	" 10 to −48
Crystallized chloride of calcium,	4	

The crystallized chloride of calcium is the most effective, on account of its remarkable solubility.

Machines constructed for freezing or cooling are all based upon the same natural laws—the absorption of heat from surrounding bodies by certain substances when they are in the act of changing their state from the liquid to the gaseous or vaporous state, or the absorption of heat from surrounding bodies by gases when they are caused to expand from a smaller to a larger volume while doing mechanical work. Liquid ammonia and ether are frequently employed as the refrigerating agents. Theoretically ammonia ought to be one of the best agents, as its latent heat and vapour tension are both high. Ammonia vapour, being much more penetrating than steam, is, however, somewhat difficult to manipulate. Sulphurous anhydride (SO_2), which is liquid at atmospheric pressure and at a temperature of −15° C., is frequently employed with advantage, as the liquid is perfectly stable, and does not act upon any of the metals or fats. From the superior vapour tension, density, and latent

heat of this liquid, as compared with ether, the compression pump of the machine need not have more than one-fourth the capacity of that employed in an ether machine to solidify the same quantity of water.

The apparatus consists of a cylindrical copper multitubular refrigerator, in which the liquid anhydride is volatilized. The vapour is then withdrawn from the refrigerator at a greatly reduced temperature and forced into a condenser by means of a double-action pump. Through the tubes of the refrigerator a solution of glycerin or of common salt is caused to circulate, which being cooled down to about $-6{\cdot}5°$ C. is then applied in the usual way to the cooling and congelation of other bodies, or the liquids may be passed direct through the tubes of the refrigerator without the intervention of the glycerin or saline solution. The condenser consists of a copper cylindrical multitubular vessel, through the tubes of which a current of cold water passes, by which the heat developed by the compression of the vapour, and by the change of the sulphurous anhydride from the gaseous to the liquid state, is removed.

Suitable pipes conduct the liquid sulphurous anhydride from the condenser back to the refrigerator, and the vapour or gas from the refrigerator to the pump, and from the pump back to the condenser, a simple arrangement of cocks and valves being adapted to the pipes for regulating the flow of the liquid and vapour. By this machine a ton of ice may be produced per hour at a cost not exceeding six shillings per ton. The importance of such refrigerating machines cannot be overestimated for cooling chambers on board vessels employed for the transport of meat and other articles of food from distant countries. Another machine, devised by Coleman, which is very extensively used, acts by sending a current of cooled and dry air through the meat chamber.

When nitrate of ammonia and water are used as a freezing mixture, on the recrystallization of the nitrate of ammonia all the heat that was absorbed in its solution is again given out, just as the latent heat of liquefaction is restored when water freezes. M. Ancelin, a French engineer, has utilized this principle in its application to railway foot-warmers. Acetate of soda demands a large amount of heat for its liquefaction, and restores it again on solidification. Its crystals liquefy when heated, and resolidify on cooling, giving out the heat that previously disappeared in liquefaction. The railway carriage foot-warmers are filled with crystals of this salt instead of water. They are then placed in a suitable oven and heated to above the boiling point of water, and thus heated are placed in the carriage. As the solution cools down, it gives out its heat in the same way as cooling water, but so soon as the crystallizing point is reached, it continues giving out heat without losing its temperature, and this goes on until all the liquid is solidified, when ordinary cooling goes on again. The warmers thus charged are found to remain heated twelve or fourteen hours, and no labour of refilling is required. They are simply again placed in the oven for liquefaction.

VAPORIZATION—GASES—VAPOURS.

When a sufficient amount of heat is applied to a body it usually assumes the gaseous state, unless it is decomposed before assuming that state. The most refractory substances, such as carbon, by the application of the intense heat of the electric current, can be converted into gases, although only in very small quantities. When a solid passes into the gaseous state it generally assumes the intermediate state of a liquid; sometimes, however, it will pass into the gaseous state without becoming liquid, and this is called *sublimation*. The passage of a liquid to the gaseous state is termed *vaporization*, but in whatever way the gaseous condition is produced it always requires a considerable amount of latent heat. A pound of water at 100° C. will absorb a large amount of heat before it is converted into steam, although the temperature of the steam will still be 100° C. The latent heat of gases is greater than that of liquids.

Elastic fluids have been divided into gases and vapours. A gas denotes a substance which under ordinary circumstances appears in the gaseous form, and which can only be reduced to the solid or liquid form by intense pressure or intense cold. A vapour is a substance in a gaseous form which at ordinary temperatures is in a solid or a liquid form. The volume of a gas at a given temperature is always inversely proportionate to the pressure to which it is subjected. Under ordinary circumstances all gases are subjected to the pressure of the atmosphere, so that the heat that increases the volume of a given quantity of gas not only does the work of expansion of the gas, but also has to overcome the atmospheric pressure, and in doing so suffers a certain loss of temperature. The expansion of gases by heat has been investigated by Regnault, who found that, with very small variations, *all gases expand equally with equal increase of temperature when subject to equal pressures, and the volume of gases varies inversely with the pressure to which they are subjected.* Regnault gives the following expansion of gases between 0° C. and 100° C.:—

Volume at 0° C. equal to 1·0000.	Under constant Pressure.	Under constant Volume.
Hydrogen,	0·3661	0·3667
Carbonic oxide,	0·3669	0·3667
Atmospheric air,	0·3670	0·3665
Nitrogen,	—	0·3668
Carbonic acid,	0·3710	0·3688
Protoxide of nitrogen,	0·3719	0·3676
Cyanogen,	0·3877	0·3829
Sulphurous acid,	0·3903	0·3845

Under the pressure of $3\frac{1}{2}$ atmospheres the coefficient of expansion of air increases from 0·367 to 0·369; carbonic acid, from 0·371 to 0·385, between 0° and 100° C.; while the expansion of hydrogen remains constant, as at one atmosphere. Gases increase about one-third of their bulk between 0° C. and 100° C., or $\frac{1}{273}$ for each degree centigrade, the unit being the volume of the gas at 0° C.; and the coefficient of expansion of gases under constant pressure is 0·00367 for each degree centigrade, the volume at 0° C. being unity. Gases undergo a corresponding contraction when their temperature is lowered, and most gases become liquid and some solidify long before reaching the $-273°$ C. This temperature, $-273°$ C., at which a body is supposed to be devoid of all heat, is termed *the absolute zero* of temperature, and temperatures calculated from this are called *absolute temperatures*. The relations between the volume, temperature, and pressure of gases have been expressed in the following terms:—

When the pressure is constant the volume of a gas varies directly as its absolute temperature.

When the volume is constant the pressure varies directly as the absolute temperature.

Volatile liquids are those which possess the property of passing at once into vapour. *Fixed* liquids are those which undergo chemical decomposition before they form vapours, such as the fatty oils, and there are many solid bodies which form vapours without first becoming liquid, such as arsenic, camphor, and in general all odoriferous solid substances. There are three kinds of vaporization:—

Evaporation, where a liquid is converted into a vapour quietly, and without the formation of bubbles.

Ebullition, where bubbles of gas are formed in the mass of the liquid itself.

Vaporization in the *spheroidal condition*, where a liquid evaporates slowly, although in apparent contact with a very hot substance.

Evaporation is the slow production of a vapour at the surface of a liquid, and it takes place even with the same liquid at very different temperatures, and is subject to the following laws:—

It varies with the temperature.

It varies with the extent of surface exposed.

It takes place very rapidly in vacuo, and more slowly when the liquid is in contact with air.

It goes on more rapidly in dry air than in air containing vapour.

Any agitation tending to renew the particles of air over the surface of the liquid produces more rapid evaporation.

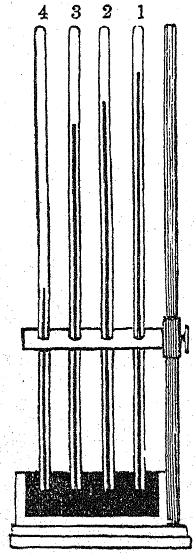
The process of evaporation is continually going on in

nature, and constitutes one of the means by which the surface of the earth is rendered fit to sustain animal and vegetable life. It is also extensively applied in chemistry and in the arts, being employed to separate a more volatile from a less volatile substance, as alcohol from water.

Vapours, like gases, have a certain elastic force, and therefore they exert pressures on the sides of vessels in which they are contained. When the liquid is freely exposed to air it changes very slowly into the vaporous condition, but in a vacuum, where there is no resistance, the formation of vapour is instantaneous.

The elasticity or tension of the vapour may easily be estimated when it is below that of the atmospheric pressure. Four barometer tubes filled with mercury are immersed in the same trough. Allow the first barometer to remain as a standard for comparison; if a few drops of water, alcohol, and ether are respectively introduced into the tubes 2, 3, 4, when the liquids reach the vacuum a depression of the mercury is at once produced by the formation of vapour. The space through which the mercury descends in the tube is the measure of the elasticity of the vapour. The depression will be found to vary in the different tubes; it is greater in the case of alcohol than in that of water, and greater with ether than with alcohol. Thus, if the mercury in the standard barometer stands at 30 inches, the temperature at the time being 26·5° C., the mercury will stand in the tube containing the water at 29 inches, in the alcohol tube at $28\frac{1}{10}$ inches, and in the ether tube at 10 inches. The elasticities of these vapours at a given temperature, measured in inches of mercury, will be—

Fig. 16.



Vapour of water,	1 inch, or	$\frac{1}{30}$	of the atmospheric	pressure.
Vapour of alcohol,	$1\frac{9}{10}$ "	$\frac{19}{30}$	"	"
Vapour of ether,	20 "	$\frac{2}{3}$	"	"

When a small quantity of a volatile liquid, as ether, is introduced into a barometer tube it is immediately vaporized, and the mercury is slightly depressed by its elasticity; on adding more ether more vapour is formed, and the mercury in the tube is further depressed. By adding further quantities of ether it finally ceases to vaporize, and remains liquid in the tube. At a certain temperature, therefore, there is a limit to the quantity of vapour which can be formed in a given space. This space is then said to be *saturated*, and there is a limit to the tension of the vapour, which varies with the temperature, but which for a given temperature is *independent of the pressure.*

According as vapours are saturated or non-saturated they present two very different states. When they are saturated and in contact with the liquid they differ entirely from gases; as with a given temperature they are neither compressed nor expanded, their elastic force and density remain constant. When vapours are non-saturated they exactly resemble gases; as their tension increases so their volume diminishes, and as their tension diminishes their volume increases, and as in both cases the volume of the vapour is inversely as the pressure, *non-saturated vapours obey Boyle's law.* A non-saturated vapour, when heated, expands its volume like that of a gas, and the coefficient of the expansion of air, 0·00366, may be taken for that of vapours, and the formulæ for the compressibility and expansibility of gases also apply to non-saturated vapours.

Gay-Lussac has measured the tension of aqueous vapours below zero. That water evaporates below zero is shown by the circumstance that wet linen exposed to the air during frost first becomes stiff and then dry, proving that the particles of water evaporate after the latter has been converted into ice.

TENSION OF AQUEOUS VAPOUR BELOW ZERO.

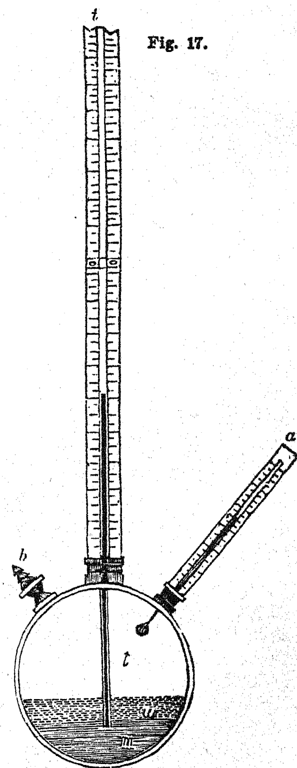
At 0° C.	the depression of the mercury column is	4·54 mm.
" 1	" "	4·25 "
" 3	" "	3·63 "
" 5	" "	3·11 "
" 7	" "	2·67 "
" 10	" "	2·08 "
" 20	" "	0·84 "
" 30	" "	0·36 "

The elasticity of aqueous vapour below the boiling point is given in the following table, as determined by Dalton:—

Temperature, Centigrade.	Elasticity in inches of Mercury.	Temperature, Centigrade.	Elasticity in inches of Mercury.
0°	0·200	32·2°	1·36
4·5	0·263	37·7	1·86
10	0·375	47·5	3·33
12·8	0·443	59·5	5·74
15·5	0·524	71·1	9·46
18·5	0·616	82·2	15·15
21·2	0·721	93·3	23·64
26·6	1·000	100	30·00

A convenient apparatus for determining the elasticity of aqueous vapours at temperatures above the ordinary boiling point, within certain limits, consists of a stout globular vessel (fig. 17) containing mercury, *m*, and water, *w*, and having a long glass tube, *tt*, open at both ends, firmly adjusted into it so as to dip into the mercury. The part of the tube which rises above the boiler has a scale attached to it, and graduated into inches and parts of inches. The globular vessel has two other openings, into one of which a stopcock, *b*, is screwed, and into the other a thermometer, *a*, having its bulb within the vessel. When heat is applied to the apparatus the vapour produced cannot escape, as all the junctions are perfectly steam-tight; the temperature, therefore, continually rises instead of stopping at the boiling point, and the vapour formed, pressing upon the surface of the liquid, and this again on the surface of the mercury beneath, forces the mercury to ascend in the tube, *tt*, till it attains a height sufficient to counterpoise, by its weight, the elastic force of the steam. The height, therefore, to which the mercury ascends may be taken to express the pressure of the steam, that is, its elasticity at any temperature above 212°. As the weight of the atmosphere is equivalent to a column of mercury of 30 inches, this force must be overcome by the steam at 212° before the mercurial gauge furnishes any indication. But this temperature being once passed, the mercury begins to rise, and every 30 inches it is forced up

Fig. 17.



the gauge-tube denotes an increase in the elastic force of the steam contained in the apparatus equal to the pressure of an atmosphere. Thus, supposing the mercury to stand in the gauge at 30 inches, the steam is said to be of 2 atmospheres, at 45 inches it is $2\frac{1}{2}$ atmospheres, at 60 inches it is 3 atmospheres, and so on. The thermometer at the same time shows the corresponding temperatures.

Regnault gives the tension of aqueous vapour from $-10°$ C. to 104° C. as follows:—

Temperatures, Centigrade.	Tension in Millimetres.	Temperatures, Centigrade.	Tension in Millimetres.
−10°	2·078	29°	29·782
− 8	2·456	30	31·548
− 6	2·890	31	33·405
− 4	3·387	32	35·359
− 2	3·955	33	37·410
− 0	4·600	34	39·565
+ 1	4·940	35	41·827
2	5·302	40	54·906
3	5·687	45	71·391
4	6·097	50	91·982
5	6·534	55	117·479
6	6·998	60	148·791
7	7·492	65	186·945
8	8·017	70	233·093
9	8·574	75	288·517
10	9·165	80	354·643
11	9·792	85	433·41
12	10·457	90	525·45
13	11·062	91	545·78
14	11·906	92	566·76
15	12·699	93	588·41
16	13·635	94	610·74
17	14·421	95	633·78
18	15·357	96	657·54
19	16·346	97	682·03
20	17·391	98	707·26
21	18·495	98·5	720·15
22	19·659	99	733·91
23	20·888	99·5	746·50
24	22·184	100	760·00
25	23·550	100·5	773·71
26	24·998	101	787·63
27	26·505	102	816·17
28	28·101	104	875·69

Regnault also shows that the elastic force of aqueous vapour increases much more rapidly than the temperature.

TENSION IN ATMOSPHERES FROM 100° TO 230·9° C.

Temperatures, Centigrade.	Number of Atmospheres.	Temperatures, Centigrade.	Number of Atmospheres.
100·0°	1	198·8°	15
112·2	$1\frac{1}{2}$	201·9	16
120·6	2	204·9	17
133·9	3	207·7	18
144·0	4	210·4	19
152·0	5	213·0	20
156·2	6	215·5	21
165·3	7	217·9	22
170·8	8	220·3	23
175·8	9	222·5	24
180·3	10	224·7	25
184·5	11	226·8	26
188·4	12	228·9	27
192·1	13	230·9	28
195·5	14		

The tension of the vapours of different liquids at various temperatures have likewise been determined by Regnault.

Liquids.	Temperatures, Centigrade.	Tension in Millimetres.
Mercury, ...	0°	0·02
	50	0·11
	100	0·74
Alcohol, ...	0	13
	50	220
	100	1695
Bisulphide of carbon, .	−20	43
	0	132
	60	1164
	100	3329
Ether, ...	−20	68
	0	182
	60	1728
	100	4950
Sulphurous acid, . . .	−20	479
	0	1165
	60	8124
Ammonia, ...	−30	876
	0	3163
	30	8832

ARITHMETIC.—CHAPTER IX.

DIVISION OF FRACTIONS.

In arithmetical language a *fraction* implies (1) that some unity is regarded as a standard, (2) that the standard unity is (or can be) divided, at least in thought, into equal parts, and (3) that these equal parts can be indicated in terms expressive or suggestive of the unity to which they refer. It is quite natural to think that the division of a unity already divided—*i.e.* a fraction—especially when that operation is to be performed through the agency of another division of unity, must be a difficult process. If, however, we remember that figures are merely representatives or symbols of values, real or conventional, and that as the unit of value changes in men's thoughts, speech, dealings, &c., so does the value of the symbols employed. For instance, speaking of money, a farthing is one-fourth of a penny, five shillings one-fourth of a pound; in regard to weight, twenty-eight pounds is one-fourth of a hundredweight, and in reference to higher figures we may say "three millions and a quarter" or "three and a quarter millions," where a quarter is equal to 250,000. The significance of a figure depends on the unit to which it refers —*e.g.* $2 \div 2 = 1$, and $\frac{1}{2} \div \frac{1}{2} = \frac{1}{4}$. In reality, therefore, each numerator is a whole number in regard to the unit to which it is referable, and which is indicated by the denominator—*e.g.* three-fourths of a shilling are ninepence ($\frac{9}{12}$); three-fourths of a pound, fifteen shillings ($\frac{15}{20}$); three-fourths of a ton, 1680 lbs. ($\frac{1680}{2240}$). It is not enough, therefore, that figures, whether integral or fractional, should be significant of *some* value; it is necessary that they should be co-significant in relation to the same unit (whatever that may be). When we bring two fractions having different denominators to two which have the same denominator, we are bringing them into correlation with the same unit, and so preparing them really to bear the relation of whole numbers (in that respect) to each other. This is the reason for the ordinary rules in the arithmetic of fractions—in order that fractions may be compared and operated upon, they must be of the same kind (*i.e.* they must have the same denominator); in other words, they must relate to the same unity. This enables us to apply the same extension of principle to division of fractions as we have already employed in multiplication (p. 698), viz. perform upon A the same operation as would be performed upon 1, in order to form B. Division being the converse of multiplication, any extension of principle applicable to the one ought to be applicable also to the other; hence the extension of the idea of multiplication advocated there requires to be (or at least may be) adopted in the case of division, where the quantity given as a divisor is a fraction.

The principle upon which this extension depends can be made very obvious. Supposing that we want to know the length of a plank, and find that a rule of 2 feet in length measures it at 5 times; we thereby know that a rule of 1 foot would measure it at 10 times; and that $\frac{1}{2}$ foot rule would require to be applied 20 times to tell its length. From this, then, it is obvious, that the smaller the measure we apply, the more times is it contained in the given length. Supposing now that we know that the length of our plank is 10 feet, and wish to ascertain into how many lengths of $\frac{2}{3}$ of a foot it may be cut, we have then this question:—

How many times does 10 contain $\frac{1}{3}$?

Now $\frac{2}{3}$ is twice $\frac{1}{3}$; the length 10 must therefore contain $\frac{2}{3}$ just half the number of times that it contains $\frac{1}{3}$. Again, every unit in 10 contains $\frac{1}{3}$ *three times;* 10 therefore contains $\frac{1}{3}$ *thirty times,* and consequently contains $\frac{2}{3}$ half as often, or *fifteen times.* This reasoning put into symbolical language is this:—

$$1 \div \frac{1}{3} = 3, \text{ and therefore } 10 \div \frac{1}{3} = 3 \times 10 = 30;$$

$$\text{hence } 10 \div \frac{2}{3} = \frac{1}{2} \text{ of } 30 = 15.$$

Popularly speaking, of course, division of fractions differs from division of integers in this respect, that (1) the dividend or the divisor, or (2) both the dividend and the divisor, are fractional *expressions,* and the operations which fall to be performed under this department of arithmetic may be of the following three sorts—viz. to divide (1) a whole number by a fractional expression, (2) a fractional expression by a whole number, and (3) a fractional expression by a fractional expression. In the first case let us take the following example:

$$\text{Divide 7 by } \frac{8}{9}.$$

$$\text{Because } 1 \div \frac{1}{9} = 9;\ 7 \div \frac{1}{9} = 7 \times 9 = 63;$$

$$\text{and therefore } 7 \div \frac{8}{9} = \frac{1}{8} \text{ of } 63 = \frac{63}{8} = 7\frac{7}{8}.$$

But from this it appears that

$$7 \div \frac{8}{9} \text{ is equivalent to } 7 \times \frac{9}{8}, \text{ for both give } \frac{63}{8} = 7\frac{7}{8}.$$

From an investigation of the operation just gone through, it appears that to divide a whole number by a fractional expression, we require (1) to multiply the whole number by the *denominator* of the divisor, and (2) to divide this product by the *numerator.* Let us see: $5 \div \frac{7}{9} = ?$ We may reason thus: unity contains one-seventh of the divisor nine times. Therefore 5 must contain one-seventh of the quotient nine times; now the seventh part of 5 is $\frac{5}{7}$, which is the ninth of the quotient, and nine times, $\frac{5}{7}$ equals $9 \times 5 \div 7 = 45 \div 7 = 6\frac{3}{7}$, answer. As this is precisely the answer we should have if we said 5, the whole number, multiplied by 9, the denominator (*i.e.* 45), and this product (45) divided by the numerator (*i.e.* $45 \div 7$) $= 6\frac{3}{7}$, we are entitled to infer that to divide a whole number by a fractional expression we must multiply the whole number by the denominator of the divisor and divide this product by the numerator.

Let us now proceed to the second case, and let us take—**Divide $\frac{8}{9}$ by 8.** That is, $\frac{8}{9} \div 8 = \frac{8 \div 8}{9} = 8 \div 8 = 1 \div 9 = \frac{1}{9}$, or since unity is the eighth part of the divisor, the quotient is the eighth part of $\frac{8}{9} = \frac{1}{9}$. We may, however, proceed otherwise, thus, as was shown in p. 698, $\frac{8}{9} \div 8 = \frac{8}{9 \div 8} = \frac{1}{9}$. We may therefore either multiply the denominator or divide the numerator of the dividend by the divisor.

In the third case, if it be said, Divide $\frac{7}{8}$ by $\frac{2}{3}$, we proceed to say $\frac{7}{8 \times 2} = \frac{7}{16}$, and $\frac{7}{16} \times 3 = \frac{21}{16} = 1\frac{5}{16}$, *ans.* Or we may bring them to a common denominator and say

$$\frac{7}{8} \div \frac{2}{3} = \frac{21}{24} \div \frac{16}{24} = \frac{21}{16} = 1\frac{5}{16}, \text{ as before.}$$

We conclude then, as a general rule, that to *divide* by a fraction is the same as to *multiply* by that fraction inverted. This may be proved with the following cases:—

$$5 \div \frac{2}{3} = 5 \times \frac{3}{2} = 1\frac{1}{2};\ 12 \div \frac{7}{11} = 12 \times \frac{11}{7} = 1\frac{4}{7}.$$

It is plain, then, that the *principle* remains the same whatever the question may be.

Exercises—

$$6 \div \frac{2}{5} = 15;\ 8 \div \frac{7}{9} = 10\frac{2}{7};\ \frac{3}{5} \div 8 = 13\frac{1}{3}.$$

The student is recommended to go over the processes of the following example very slowly and observantly.

Let it be required to divide $\frac{3}{4}$ by $\frac{5}{7}$.

$$\text{Because } 1 \div \frac{1}{7} = 7, \text{ therefore } \frac{1}{4} \div \frac{1}{7} = \frac{1}{4} \text{ of } 7 = \frac{7}{4};$$

$$\text{and } \frac{3}{4} \div \frac{1}{7} = 3 \times \frac{7}{4} = \frac{21}{4}, \text{ and therefore}$$

$$\frac{3}{4} \div \frac{5}{7} = \frac{1}{5} \text{ of } \frac{21}{4} = \frac{21}{20};$$

$$\text{but conversely } \frac{21}{20} = \frac{3 \times 7}{4 \times 5} = \frac{3}{4} \times \frac{7}{5} = \frac{3}{4} \div \frac{5}{7}.$$

We may review the question differently. According to the nature of division, the *divisor* multiplied into the *quotient* must give back the *dividend,* that is (taking the same fractions) $\frac{5}{7} \times$ *quotient* $= \frac{3}{4}$.

Now these equal quantities, when each is multiplied by the same quantity, must still be equal; let them therefore be both multiplied by $\frac{5}{7}$, that is, let $\frac{7}{5} \times \frac{5}{7} \times$ *quotient* $= \frac{3}{4} \times \frac{7}{5}$

But $\frac{7}{5} \times \frac{5}{7} = \frac{35}{35} = 1$; and any quantity multiplied by unity is not altered in magnitude; therefore the above fractional expression is reducible to *quotient* $= \frac{3}{4} \times \frac{7}{5} = \frac{21}{20}$, and this is the same result as that at which we have previously arrived. It must be admitted, however, that a proof conducted in this manner is rarely satisfactory to the beginner; and as it is for such that we write, we may supply the following simple solution, which is also more direct:—

Let the given fractions $\frac{3}{4}$ and $\frac{5}{7}$ be reduced to a common denominator; they then become $\frac{21}{28}$ and $\frac{20}{28}$. Now as these fractions express the same kind of subordinate units, it is clear that $\frac{21}{28}$ divided by $\frac{20}{28}$ must give the same result as 21 divided by 20; that is, $\frac{21}{20}$, which is equivalent to $\frac{3 \times 7}{4 \times 5}$.

$$\text{Exercise—Divide } \frac{3}{4} \text{ by } \frac{2}{3} = 1\frac{1}{8};\ \frac{1}{2} \div \frac{1}{8} = 4;$$

$$\frac{4}{5} \div \frac{1}{3} = 2\frac{2}{5};\ \frac{3}{5} \div \frac{8}{11} = \frac{33}{40};\ \frac{8}{3} \div \frac{16}{21} = \frac{2}{7}.$$

From all these ways then of considering the operation of the division of fractions, we arrive at this definite general rule:—

To divide by a fraction, invert its terms and multiply.

The following are examples of the application of this rule:

$$\frac{1}{3}\div\frac{2}{5}=\frac{1}{3}\times\frac{5}{2}=\frac{5}{6} \qquad \frac{3}{7}\div\frac{5}{8}=\frac{24}{35}$$
$$\frac{3}{8}\div\frac{4}{3}=\frac{3}{8}\times\frac{3}{4}=\frac{9}{32} \qquad \frac{15}{19}\div\frac{8}{11}=\frac{165}{152}.$$

When the numerators and denominators have any common factors, the work may—as has formerly been explained (pp. 514 and 699)—be simplified by striking them out before performing the division.

$$\text{Thus, } \frac{27}{35}\div\frac{18}{55}=\frac{9'\times3}{5'\times7}\div\frac{9'\times 2}{5'\times11}=\frac{3}{7}\div\frac{2}{11}=\frac{33}{14}.$$

When integers are joined to the fractions, the easiest mode of proceeding is, transform the mixed quantities into improper fractions, and then proceed as directed in the rule.

$$\text{Thus, } 2\frac{1}{3}\div 4\frac{3}{4}=\frac{7}{3}\div\frac{19}{4}=\frac{7}{3}\times\frac{4}{19}=\frac{28}{57}.$$

The preceding are the operations which the student will frequently find himself called upon to perform in fractional arithmetic. They are usually supposed to present extraordinary difficulties, and it must be admitted, that to a person who has never studied the *rationale* of the rules employed, they are not over-intelligible. Everything depends upon having clear and precise ideas of the nature of fractional quantities, and of the relations which the operations to be performed upon them bear to the analogous processes performed upon the whole numbers.

MISCELLANEOUS QUESTIONS IN FRACTIONAL NUMBERS.

The following questions will test the progress which the student has made up to this point.

Find the sum, difference, and product of $\frac{3}{4}$ and $\frac{3}{5}$. *Ans.* $\frac{27}{20}$; $\frac{3}{20}$; $\frac{9}{20}$.

Divide 1 by $\frac{17}{23}$. *Ans.* $1\frac{6}{17}$.

Divide $\frac{7}{9}$ by 14. *Ans.* $\frac{1}{18}$.

Divide the sum of $\frac{1}{2}$ and $\frac{1}{3}$ by the sum of $\frac{1}{3}$ and $\frac{1}{4}$. *Ans.* $\frac{10}{7}$.

Find $\frac{1}{2}$ of $\frac{1}{3}$ of $\frac{1}{4}$ of $\frac{1}{5}$, and multiply the result by 10. *Ans.* $\frac{1}{12}$.

Multiply $\frac{1}{2}$ of $\frac{2}{3}$ by $\frac{3}{4}$ of $\frac{4}{5}$, and divide the result by $1\frac{1}{4}$. *Ans.* $\frac{4}{25}$.

Add together $2\frac{1}{2}$ and $\frac{1}{6}$, and divide the result by $3\frac{1}{2}-\frac{1}{8}$. *Ans.* $\frac{64}{81}$.

Divide $\frac{6}{7}$ of $\frac{1}{2}$ of $\frac{3}{10}$ by $\frac{6}{11}$ of $\frac{7}{8}$ multiplied by $4\frac{1}{2}$. *Ans.* $\frac{44}{735}$.

Divide the product of $\frac{21}{16}$ and $\frac{10}{7}$ by $\frac{1}{8}$ of 15. *Ans.* 1.

A's share was $\frac{27}{38}$, of which he sold $\frac{3}{4}$, how much remained? *Ans.* $\frac{27}{152}$.

$20\div\frac{8}{13}$. *Ans.* $32\frac{1}{2}$.

$\frac{5}{7}\div10$. *Ans.* $\frac{1}{14}$.

A man performed a journey in $6\frac{13}{18}$ hours; what part of the journey did he perform in 1 hour? *Ans.* $\frac{18}{121}$.

A gave B $\frac{3}{4}$ of his share, and B gave C $\frac{4}{5}$ of what he got; how much of A's share did C get? *Ans.* $\frac{3}{5}$.

The line A is equal to $\frac{4}{5}$ of the line B, and the line B is equal to $\frac{3}{4}$ of the line C; what part is the line A of the line C? *Ans.* $\frac{3}{5}$.

THE LATIN LANGUAGE.—CHAPTER X.

ETYMOLOGY OF PREPOSITIONS AND THEIR USE IN FORMING COMPOUND WORDS.

PREPOSITIONS are a great deal more used in English than in Latin. The connection between objects, which is shown in Latin by putting nouns in certain cases, is indicated by placing prepositions before them. But from the circumstances in which objects are related to each other it is found to be impossible to distinguish them accurately from one another by the six cases which constitute the forms of the Latin declensions. For instance, *Lecto jacet* might mean either "He lies on the bed" or "He lies under the bed," but which idea is the correct one could not be known from the expression. This is made clear when, leaving the former to signify "He lies on the bed," we use *Sub lecto jacet* to mean "He lies under the bed." For a similar reason we use the sentence, *In patriâ mortuus*, He died in his native land, and *Pro patriâ mortuus est* for He died for (the sake of) his native land. In point of fact, the six cases may be divided, according to the relations they generally express, into three couples. A similarity of relation may be traced (1) between the nominative and vocative cases, as denoting the subjects of discourse; (2) between the genitive and the ablative, in the use of which the attention is drawn backward to the cause of a thing, or the source or medium of an action; (3) between the dative and the accusative, in the use of which the attention is directed forward to some end accomplished or purpose given effect to. This similarity of indication seems to explain the reason why we find some declined words having a double construction, the genitive being frequently varied by the ablative with or without the prepositions *a*, *ab*, *de*, *e*, *ex*, or *in*, and the dative being occasionally varied by the accusative; so that *Utilis huic rei*, Useful for this purpose, and *Utilis ad hanc rem*, Useful to this end, are nearly equivalent expressions.

Many relations of space (and even of time) are invariably expressed by the cases of nouns without the use of prepositions, and even when prepositions are used the case which any preposition governs denotes a relation analogous to the preposition itself; for example, *Natus ad gloriam*, Born for glory, in which *ad*, with the accusative *gloriam*, points to the purpose or object for which the person is born.

If we consider the idea "whence" (*unde*) to denote source, origin, cause, &c., we shall have the root-notion of the genitive case; that of "where" (*ubi*) as implying juxtaposition, proximity, accession, rest, and presence, the main ideas of the dative, as the case of advantage or agency given or gotten, as well as of the ablative of agency, of manner, and of place in which the giving and receiving occurred; and that of "whither" (*quo*) as indicating transition to a distance, the end or object of motion, we have the radical notion of the accusative case. These different cases have attracted to themselves these general significations, and indicate them by special characteristics of termination; but all the most deter-

minate impressions of rest, motion, agency, &c., require to be suggested to the mind, not only by the use of a case—the accusative or ablative—but also by the employment of some precisely defining prepositions being placed before these two cases.

The etymology of prepositions and a knowledge of their original significations not unfrequently enable a thoughtful student to trace the idea by which usage has, in the long-run, been guided in appropriating to each a more or less defined duty in the expression of thought. The following list will be found informing upon this point, as well as suggestive of the reasons under the influence of which the government of prepositions has come to be settled as it has now been; and of how, in the striving of men to make their language expressive of clear and definite logical distinctions, they found it necessary to employ economical methods of indicating specialties of position, tendency, agency, &c., without a superabundance of explanatory interruption of the flow of their own thoughts or the exercise of the thoughts of others.

The following prepositions are derived from the Greek, and carry with them into their usage a good deal of their original significance and influence:—

A, ab, abs, absque (Gr. apo), *from* (a place, time, object, &c.)
Ante (Gr. anti), *over against*, *opposite*, *before*.
Apud (Gr. apto, *I fasten*, *fit;* also ad pedes, *at the feet of others*), with. [Dr. Donaldson regards this as a compound of *ab* and *ad.*]
Circa, circum, circiter (Gr. kirkos, kirkon, *a circle*, *ring*, *hoop*).
Cis (with *c* for *h*, as In his locis, *in these places*, or Gr. keise), *thither;* ci-tra (ce in hic-ce; trahens).
Clam (Gr. kalupto, *I cover with something;* klepto, *I conceal*, *I steal;* celo, *I hide*), *without the knowledge of.*
Coram (Gr. choran, accusative of chore, [*a proper*, *assigned*, *legitimate*] *place*), *in presence of.*
Cum (Gr. sun, ksun), *together with* (in common).
De (Gr. dia), *right through*, *away from.*
Erga (Gr. orego, oreo, *I stand towards*, *am in favour of.*)
E, ex, extra (Gr. ek, ex), *out* (*side*) *of.*
In (Gr. en), *inside of.*
Ob (Gr. hepo or hepomai, *I follow*, either to pursue or to back up).
Palam (Gr. pelas), *near*, *neighbouring.*
Per (Gr. peri, *round about*, in the relation of circumference to centre).
Præ, præter, (Gr. para), Pro, prope, propter, (Gr. pro), *side by side*, *alongside*, *beside.*
Sine (Gr. aneu), *without*, *away from*, *except.*
Sub, subter (Gr. hupo), *from under*, *beneath*, in place or subordination.
Super (Gr. huper), *above*, in place (and protectingly).
Tĕnus (Gr. teino, *I stretch*, *strain*).
Versus, versum (Gr. eiro, *I join*, *fasten;* eruo, *I draw along*).
Usque (Gr. eos ke), *until*, *so long as*, *up to.*

The derivation of the following from the accompanying Latin words will be seen quite plainly at a glance:—

Ad, see apud, of which it is an abbreviation—a(pu)d.
Adversum, see versus, of which it is an intensative.
Contra, cumtra (traho, *I draw*).
Infra, infra (fero, *I carry*).
Intra, intra (traho, *I draw*).
Juxta, junxta (jungo, *I join*).
Penes (pendeo, *to hang* or *depend upon*).
Pone *and* post (pono, *I put* or *place*, positus, postus).
Secundum (sequundus, *I follow;* sequor), *before*, in place, degree, time, cause, number, &c.
Trans (trahens, traho, *I draw*).
Ultra (ultera, *further off*).

Many prepositions are also used to form compound words, especially verbs and adjectives. They in such cases modify, by their own meaning, that of the words to which they are joined. These prepositions themselves also often undergo some change in their pronunciation or orthography, on account of the initial letter of the primitive words to which they are prefixed. As regards this matter, however, there is really in classic writers no established usage. We find, for example, in some *adloquor*, and in others *alloquor*. In like manner we have *impono* and *inpono*, *conlega* and *collega*, &c. But the system of assimilation is now very general, and in modern printed works is usually preferred.

The following ten prepositions remain unchanged in composition:—

Ante,	*Ante*pono, *I place before.*	Post,	*Post*pono, *I place after.*
Circum,	*Circum*eo, *I go round.*	Præ,	*Præ*fero, *I carry before.*
De,	*De*traho, *I draw down.* / *De*color, *without colour.*	Præter,	*Præter*eo, *I go past.*
Per,	*Per*ficio, *I do thoroughly.* / *Per*iniquus, *exceedingly unjust.*	Subter,	*Subter*labor, *I slip beneath.*
		Super,	*Super*sto, *I stand upon.*
		Trans,	*Trans*eo, *I go across.*

Trans often becomes *tra*, *e.g.* *trado*, I yield; *trajicio*, I throw; *trano*, I swim across.

Per, *præ*, and *pro* are practically the same in composition as when single; *præ* signifies *very much* or *before* in the composition of adjectives; *præ* and *pro*, *before*, in the composition of verbs; and *per*, usually *extremely* or *thoroughly*, *through*, *entirely without*, in all parts of speech; as *percarus*, very dear; *perfidus*, without faith; *prædives*, very rich.

The following eight prepositions undergo changes by assimilation. When *ad* is compounded with *pono*, though *adpono* is used by many of the best scholars, the compound is often written *appono*, the *d* at the end of *ad* being changed into *p*, the letter at the beginning of *pono*. Where the letter at the end of a preposition is changed into the letter that begins the word with which it is compounded it is said to be assimilated, or made the same as (like it). These assimilative or euphonic changes may be most clearly exhibited in the tabular form given below. The force or significance of each preposition in composition will be seen from the meaning of the compound.

A before				
m and *v*,	becomes	*a-;*	amoveo,	*I move away.*
other letters,	becomes	*ab-;*	abrado, / abeo,	*I shave away.* / *I go away.*
Ad before				
vowels and *d*, *j*, *m*, *v*,	becomes	*ad-;*	adeo, / admoveo,	*I go to.* / *I move to.*
other letters,	becomes	*assimil.;*	appono,	*I place beside.*
Cum or *Com* before				
b, *m*, *p*,	becomes	*com-;*	compono,	*I place together.*
l, *n*, *r*,	becomes	*assimil.;*	collido,	*I dash together.*
vowels,	becomes	*co-;*	coeo,	*I go together.*
other letters,	becomes	*con-;*	contraho,	*I draw together.*
Ex before				
vowels and *c*, *p*, *q*, *s*, *t*,	becomes	*ex-;*	exoro, / expono,	*I beg earnestly.* / *I place out.*
f,	becomes	*assimil.;*	efficio,	*I do completely.*
other letters,	becomes	*e-;*	ejicio,	*I throw out.*
In before				
b and *p*,	becomes	*im-;*	impono,	*I place in.*
l and *r*,	becomes	*assimil.;*	irrumpo,	*I break into.*
gn,	becomes	*i-;*	ignavus,	*not-*, *in-active.*
other letters,	becomes	*in-;*	incurro, / indoctus,	*I run into.* / *not-*, *un-learned.*
Ob before				
c, *f*, *g*, *p*,	becomes	*assimil.;*	oppono,	*I place against.*
other letters,	becomes	*ob-;*	obvenio,	*I come face to face.*
Pro before				
vowels,	becomes	*prod-;*	prodeo,	*I go forward.*
other letters,	becomes	*pro-;*	propugno,	*I fight for.*
Sub before				
c, *v*, *g*, *m*, *p*, *r*,	becomes	*assimil.;*	surripio,	*I snatch from under.*
sp,	becomes	*su-;*	suspiro,	*I breathe up* (*I sigh*).
other letters,	becomes	*sub-;*	subeo, / subtristis,	*I go under.* / *somewhat sad.*

In the case of composition with prepositions, the preposition comes first. The root-word that follows often remains unaltered. But *ă* short is generally changed into *ĭ;* as *ăd* and *făcio* make *affĭcio*. And *ĕ* short is often changed into *ĭ;* as *abs* and *tĕneo* make *abstĭneo*. *Æ* is often changed into *ī;* as *in* and *cædo* make *incīdo*, &c.

If the perfect of a simple verb has a syllable more than the present, the first syllable is usually rejected in the perfect of its compounds. Thus *cædo* has in the perfect *cecidi*, but the compound *incido* has (not *incecidi*, but) *incidi*. The compounds of *do*, *sto*, *disco*, and *posco*, however, retain their first

syllable. Some of the compounds of *curro* have their perfect formed in both ways. Those verbs which change *a* of the present into *i* have generally *e* in the supine; *e.g.* the supine of *facio* is *factum*, that of *officio* is *affectum*. To this remark, however, the compounds of *placeo*, *habeo*, *salio*, *statuo*, and of verbs ending in *do* and *go*, are exceptions.

A preposition in composition frequently governs the same case as it governed out of composition, and in its own right; as *Detrudunt naves scopulo* = *Trudunt naves scopulo*, They push the ships from the rock; *Prætereo te insalutatum* = *Eo præter te insalutatum*, I pass you unsaluted.

But verbs compounded with *a*, *ab*, *ad*, *con*, *de*, *e*, *ex*, and *in* sometimes elegantly repeat the same prepositions with their cases out of composition; as *In jugo insistere consueverunt*, They were accustomed to stand upon the yoke; *Abstinuerunt a vino*, They abstained from wine. In other cases they frequently indicate special meanings by the use of a different preposition; as *Lunam e curru deduxit*, Led (*i.e.* withdrew) off the moon (Luna) from her car.

Verbs compounded, as in the examples given below, with the prepositions *ad*, *ante*, *con*, *in*, *inter*, *ob*, *post*, *præ*, *sub*, *super*, govern the dative; as *Assidet foco*, He sits by the hearth.

Instances of these compounds are—(1) *adsto*, *accumbo*, *acquiesco*, *assideo*, *adhæreo*, *admoveo*; (2) *antecello*, *ante-eo*, *anteverto*; (3) *consono*, *commisceo*, *commorior*; (4) *illudo*, *immorior*, *immoror*, *inhæreo*, *insideo*, *inhio*, *innitor*, *invigilo*, *incumbo*; (5) *interpono*, *intervenio*, *intersero*; (6) *obrepo*, *obtrecto*, *occumbo*; (7) *postpono*, *posthabeo*; (8) *præeo*, *præluceo*; (9) *succedo*, *succumbo*; (10) *supersto*, *supervenio*.

Some prepositive particles, as *am*, *di* or *dis*, *re*, *se*, *con*, *ne* and *ve* (erroneously classed as prepositions), are called inseparable prepositions, because they are never found used except in compound words.

Amb, *ambi*, *am* or *an*, about, around; as *ambio*, I go round about, I surround. The *m* is changed into *n* before *c*, *q*, *f*, *h*; as *anceps*, that may be taken two ways, doubtful; and *b* is inserted before a vowel; as *ambio*.

Con is used for *cum*, together with; as *conjungo*, I join together, I unite; *conduco*, I lead together, I bring along with me; *confero*, I carry together. It sometimes increases the meaning; as *premo*, I press; *comprimo*, I press together, I press much; and it is sometimes, for euphony's sake, assimilated to the first consonant of the verb; as *colloco*, *corrumpo*, *cohibeo*, *complector*. In such cases *n* is dropt before a vowel or *h*, and is changed into *m* before *b*, *p*, *m*; as *cogo* (*conago*), I drive together; *cohæres*, a coheir, an heir in participation.

Di or *dis*, asunder, separately; as *disjicio*, I throw apart; *diduco*, I lead asunder, I separate. It sometimes reverses the meaning; as *facilis*, easy; *difficilis*, difficult; *fido*, I trust; *diffido*, I distrust; and sometimes increases or intensifies it; as *cupio*, I desire; *discupio*, I desire much. Dis is used before *c*, *f*, *j*, *p*, *q*, *s*, *t*, and *di* before the other consonants.

Ne prefixed to words has a negative signification; as *fas*, justice; *nefas*, injustice, impiety; *scio*, I know; *nescio*, I know not, I am ignorant.

In such words as *incautus*, *indoctus*, *imparatus* the particle *in* seems to have more connection with the *ne* or the negative letter *n* than with the preposition *in*.

Re, back, again, against, in return; as *rejicio*, I throw back; *reduco*, I lead back; *refero*, I carry back; *relego*, I read again; *reclamo*, I cry against. It sometimes reverses the meaning; as *tendo*, I bend; *retendo*, I unbend. *D* is inserted before a vowel; as *redeo*, I return.

Se, apart *or* aside; as *seduco*, I lead aside *or* apart. With adjectives it denotes privation; as *cura*, care; *securus*, free from care, careless.

Ve, little, in a small degree; as *vecors*, deficient in sense; *vesanus*, sickly.

Cum is added as an enclitic to the personal, reflexive, and relative pronouns; as *mecum*, *nobiscum*, *tecum*, *vobiscum*, *secum*, *quocum*, *quicum*, *quibuscum*, &c.

In is frequently understood before words signifying place; *terra*, *mari*, *domo*, *cælo*, *campis*, *libro*, &c.

Latin prepositions are sometimes compounded together; as *Ex adversus eum locum*, From over-against that place; *Ex adversum Athenas*, From opposite Athens; *In ante diem quartum Kalendarum Decembris distulit*, i.e. *usque in eum diem*, He delayed till the fourth day before the Kalends of December, *i.e.* up till that day—26th November; *Supplicatio indicta est ex ante diem quintum Idus Octob.*, i.e. *ab eo die*, A public thanksgiving was decreed the fifth day before the Ides of October, *i.e.* from that day—11th October; *Ex ante pridie Idus Septembris*, From the day before the Ides of September. But a good many prepositions thus compounded together may very frequently be construed as adverbs or conjunctions; as *propalam*, *protinus*, *insuper*, &c.

Instar, after the fashion of; *causa*, *gratia* (and in law-style *ergo*), for the sake of, are in reality cases of nouns used prepositionally; viz. *instar*, accusative neuter, with *ad* understood; as *Instar montis equum ædificant*, They build up a (wooden) horse as high as a mountain; *Epistola quæ voluminis instar erat*, A letter that was as good as a volume; *Clientes appellari mortis instar habent*, To be called clients seems death to them. *Causa* and *gratia*, ablatives of manner (like *nomine*, *crimine*) govern the genitive, and generally follow their case. When they do so, they may be called post-positions; as *Honoris tui causa huc ad te venimus*, We are come to meet thee here for thy honour's sake; *Virtutis ergo*, In recognition of bravery.

With *causa* the genitives *mei*, *tui* are replaced by the ablatives *mea*, *tua*; as *Te abesse mea causa moleste fero*, *tua gaudeo*, I grieve at your absence for my sake, I rejoice at it for yours; *Aliena potius causa quam sua*, More for the sake of another than for his own.

From some of these prepositions adjectives are derived, (1) of the positive degree; as *contrarius*, opposed to; *exter* or *exterus*, outside, foreign; *inferus*, below, underneath; *posterus*, following, future; *superus*, above, upper, higher; and (2) of the comparative and superlative degree; as

Citra, *citerior*, *citimus*, nearer, smaller, earlier, next, least, latest.

Extra, *exterior*, *extremus* and *extimus*, outer, further, outmost, furthest.

Infra, *inferior*, *infimus* and *imus*, lower, lowest, baser, basest.

Intra, *interior*, *intimus*, within, inner, innermost.

Post, *posterior*, *postremus* and *postumus*, late, later, latest.

Præ, *prior*, *primus*, previous, former, first.

Prope, *propior*, *proximus*, near, nearer, next, last.

Supra, *superior*, *supremus* and *summus*, above, upper, loftier, topmost, highest.

Ultra, *ulterior*, *ultimus*, further, first, extreme, last.

Ante, *circa*, *circum*, *circiter*, *citra*, *extra*, *infra*, *intra*, *juxta*, *pone*, *post*, *prope*, *supra*, *ultra*, *clam*, *coram*, *palam*, *super*, *subter*, are also often used as adverbs.

READING LESSON.

SECTION I.—TRANSLATION AND RETRANSLATION.

The chief difficulty of translating Latin into English or English into Latin arises from the difference of order in the arrangement of the words which constitute sentences. A mere transference of words in one language into words of similar signification in the other, or a word-for-word version, will not suffice. In English the relations of words are more or less those of place, and their meaning in the sentence is mainly determined by the position they occupy in it. But in Latin the relations of words are indicated by case, and the inflexions of words indicate their relations, in whatever order they are put. For example, in English we can only express the same fact with these three words in one way—Cæsar overcame the Nervii; but the Romans could, according to the special intention of the usage, express that same fact in the following four ways: *Cæsar vicit Nervios; Nervios vicit Cæsar; Cæsar Nervios vicit*; *Nervios Cæsar vicit;* and in each of these forms the signification would be obvious, because the termination of *os* in *Nervios* indicates the relation of that word in thought to be that of the object of the operation of the verb. Each language has a simple or grammatical order in accordance with which words are generally arranged, and the laws of this order are set forth in the syntax of the language. Within the limits of the syntax of each language, however, there are certain rhetorical inversions or artistic arrangements of the words of sentences to give them

an unusual, and therefore more striking or more agreeable, effect. Even in English, on this account, the simple line in Gray's Elegy—

"The ploughman, homeward, plods his weary way,"

may be varied into twelve different and equally intelligible sentences.

Each nation, regarding its own habit of thought and speech as natural, considers the arrangement of words required by the syntax of another land's language artificial, and the difficulty felt in attaining idiomatic felicity of expression mainly results from a certain want of facility in casting our ideas into the syntactic forms which these languages prefer.

All Latin composition, in its arrangement of words, seems of course artificial to us, because it differs from our own, and unless we learn, as nearly as possible, to think as the Romans thought—or at least get into the habit of giving our thoughts the turn they gave theirs—we shall always feel it difficult to speak as the Romans spoke. If it is asked, How is this to be attained? no better reply, we fear, can be given than this—by the study and imitation of the classics. The student who watches how the classic writers compose their sentences, so as to make them at once agreeable to the ear and suggestive to the mind, will readily, after some careful reading and a fair amount of diligent practice, acquire the turn of thought and idiomatic felicity of phrase which distinguish their language; will feel, appreciate, and be able to reproduce the different kinds of style which are best adapted to different kinds of composition—historical, poetical, political, or philosophical, as the case may be; and may even succeed in imparting to his Latinity the vigour of Cæsar, the terseness of Livy, the glowing fluency of Virgil, the crisp grace of Horace, the pliant variousness of Cicero, the sententiousness of Cato, or the majestic force of Lucretius.

In the earlier stages, however, either of translation or composition, it is advisable to attend particularly to the structure of simple sentences, and to the various modes in which these are arranged; to notice the interdependence of inflexion and syntax; and to give special heed to the employment and place of uninflected words. Endeavours should also be made, after bringing words together into the order of English, and translating them so, to trace the accuracy and beauty of the phraseology in the relations imposed by their syntax, and then to give careful thought to the transfusion of that expressiveness and elegance into the versions we prepare. This custom of fixing the mind on the idea to be expressed, in the special relation in which it is to be presented, and of seeing how, on the one hand in Latin, and on the other in English, it may be *phrased* with pellucid precision and entire fidelity—matched with twin-like similarity as counterparts—is one of the greatest of the practical intellectual benefits of the study of a classical language, such as Latin.

In our consideration of the matter to be adopted for reading lessons in Latin, the advantage of taking distinctly classical passages, every word of which would be a specific acquirement, and every sentence of which, when carefully studied and fairly comprehended, would be a definite step taken, pressed itself upon our minds. In Cæsar we had such matter, spoken of in a clear and accurate style, by one who possessed a personal knowledge of, and had been an actor in, much of what he relates. The historical interest of the narrative, and the unadorned simplicity of the style, seemed to promise that those who learned what Cæsar said, in the way that he had said it, would have nothing to unlearn, either as to diction or syntax, and to justify the choice of the writings of the most fully cultured man of his age for an introduction to the study of Latin prose. We have the hope that the vocabulary supplied, the translations given, the explanation afforded, and the imitative exercises through which the gradual growth of sentences similar to those of Cæsar is exhibited, in such a manner that they are each brought at last into harmony with the text, and can be compared with the original, will commend themselves in their results as a useful, easy, and pleasant aid to the simultaneous acquisition of the power of reading and of writing Latin. Cæsar tells us how that brave and powerful Celtic race which dwelt in what we might now call Western Switzerland began to bethink themselves of seeking a new home in the more fertile plains of Gaul. Having described Gaul generally, he now presents further information upon the Helvetii, their leader, territories, condition, aspirations, and designs.

Section II.—Cæsar's Gallic War, Book I., Chap. 2.

The Leader of the Helvetii.—Apud Helvētios longe nōbĭlissĭmus et dĭtissĭmus fuit Orgĕtŏrix.

Their Compact and its Purpose.—Is, M. Messāla et M. Pīsōne consŭlibus, regni cŭpĭdĭtāte inductus conjūrātiōnem nŏbĭlĭtātis fēcit, et cīvĭtāti persuasit, ut de finibus suis cum omnibus cōpiis exīrent: perfăcĭle esse, cum virtūte omnibus præstārent, totĭus Galliæ impērio pŏtīrī.

The Territories of the Helvetii.—Id hōc făcĭlius ĕis persuasit, quod undique lōci natūra Hĕlvĕtii contĭnentur: ūna ex parte flūmĭne Rhēno, lātissĭmo atque altissĭmo, qui agrum Hĕlvĕtium a Germānis dĭvĭdit; altĕra ex parte monte Jūra altissĭmo, qui est inter Sequanos et Hĕlvĕtios; tertia lācu Lĕmanno et flūmĭne Rhŏdăno, qui provinciam nostram ab Helvetiis dividit. His rebus fiēbat, ut et mīnus lāte văgārentur et mīnus făcĭle finĭtĭmis bellum inferre possent: qua de causa [some read qua ex parte] homines bellandi cŭpĭdi magno dŏlōre afficiēbantur. Pro multĭtūdĭne autem homĭnum et pro glōria belli atque fortĭtūdĭnis angustos se fines habēre arbĭtrābantur, qui in longĭtūdĭnem millia passuum dŭcenta et quadrăginta, in lātĭtūdĭnem centum et octōginta patēbant.

Section III.—Vocabulary.

(N.B.—*Words given in the vocabulary to the previous chapter, pp.* 702–704, *are not repeated in this.*)

Affĭcio, fēci, fectum, ficere, verb neut. (facio), *to do* (something) *to* (a person or thing); in passive—

Affĭcior, fectus sum, fĭci, *to be afflicted, punished* (*for, by, with*), &c.

Ager, gri, *a field, land, estate, territory.* [Distinguish between this and the following words: terra, æ, *the earth*, as opposed to the sea; sŏlum, i, *the ground* or *bottom, that on which anything rests, the soil* for cultivation].

Altus, a, um, adj. *high, deep, i.e.* high from the bottom. [Distinct from altus, part. (from alo, alui, alitum, alere, *to nourish*), *fed, nourished*].

Anguste, adv. *narrowly.*

Angustiæ, ārum, fem. *narrowness, straits, difficulty, a defile* (from ango, anxi, —, ĕre, trans. *to compress, to strangle, to vex, to torment*).

Angustus, a, um, adj. *narrow, strait, close, confined.*

Atque (ad and que), conj. *and, and also.*

Autem, conj. *but, moreover, besides.* Autem, ĕnim, vēro, quŏque, quĭdem never begin a clause or sentence.

Bellandi, gerund in di (from bello, āvi, ātum, āre).

Bellĭcus, a, um, *and* bellicōsus, a, um, adj. *warlike, martial, valorous.*

Bello, āvi, ātum, āre, intrans. *to wage war.*

Bellum, i, neut. *war.* Contraction for duellum, i, neut. *a contest between two, a duel.*

Centum, card. indecl. num. adj. *a hundred* [C.]

Cīvis, is, com. gen. *a citizen.*

Cīvĭtas, ātis, fem. (from cīvis, is, mas. and fem, *a citizen*), *the citizens collectively, the state, citizenship, the freedom of the city.* Compare urbs, urbis, fem. *a city*, and oppĭdum, i, neut. *a town*, with reference to the houses.

Concilium, i, neut. *an assembly for hearing, a meeting, a council.*

Conjūrātio, ōnis, fem. *a confederacy, a conspiracy.*

Conjūro, āvi, ātum, āre, intrans. (from con and juro), *to swear together, to swear allegiance, to conspire, to enter into a conspiracy.*

Consĭlium, i, neut. *a consultation, a plan, prudence, determination, a council of war, a deliberative assembly.*

Consul, ŭlis, mas. *a consul.* The name applied to each of the two supreme magistrates who were annually elected by the whole of the people, in *comitia centuriata*, at Rome after the overthrow of the regal government, B.C. 510, to be at the head of affairs, and to direct all things in peace and war.

Consŭlāris, is, e, adj. *of* or *belonging to a consul; of consular dignity.*

Consŭlātus, ūs, mas. *the consulship;* from consŭlo, ui, tum, ĕre, trans. with acc. *to consult, to ask advice;* with dat. *to consult for, to attend to the interest of* (reipublicæ) the state, for example, which it was the duty of the consuls to do.

Cōpia, æ, *plenty, store, number;* hence *power, force*, or plur. copiæ, ārum, *forces.*

Copiōsus, a, um, adj. (from con, *together*, and ops, ŏpis, fem. *power*, *might;* plur. opes, um, *wealth*, *resources*), *abundantly supplied*, *wealthy*.

Cŭpĭdĭtas, tatis, *desire*, *passion*, *love*.

Cŭpĭdus, a, um (cupio, īvi *or* ii, ītum, ĕre, verb act. *to feel favourably disposed to*), *desirous*, *eager*, *zealous*.

Dē, prep. *from*, *down* or *out from*, *of* or *concerning*.

Dīvĕs, ĭtis, adj. *rich* (divitior, divitissimus); also dīs, dīs, dīte; gen. dītis (dītior, ditissimus).

Dŏlor, ōris (dŏleo, ui, itūm, ēre, *to grieve*), *grief*, *sorrow*.

Ducenti, æ, a, card. num. adj. *two hundred* [CC.]

Esse, infin. of sum, fui, esse, verb irreg. *to be*.

Exeo, īvi *or* ii, ĭtum, īre (ex and eo), irreg. intrans. *to go out*, *to go out of*.

Făcile (for faciliter), adv. *easily* (facilius, facillime).

Făcĭlis, is, e (facio), adj. *what may be done*, *easy* (facilior, facillimus).

Facilius, adv. (comp. of facile, *easily*). See *perfacile*.

Făcio, fēci, factum, ĕre, *to make* or *form*, *to do*.

Fīnis, is, mas. *or* fem. *an end*, *limit*, *boundary;* plur. fines, *frontiers*, *territories*. Hence finio, īvi, ītum, īre, trans. *to limit*, *to terminate*, *to assign*.

Finitimi, ōrum, mas. *neighbours*.

Finĭtĭmus, a, um, adj. *neighbouring*, *bordering*.

Fio, factus sum, fieri, verb quasi-pass., *to be made*, *happen*.

Flūmen, ĭnis, neut. *a river*, *a stream*. [Flŭvius, i, mas. and amnis, is, mas. also denote a river, the two former in opposition to a lake, and the latter to a sea; flumine sĕcundo, *down* or *along with the stream;* flumine adverso, *against* or *up the stream.*]

Flūmĭneus, a, um, adj. (from fluo, fluxi, fluxum, ĕre, intrans. *to flow;* hence fluctus, ūs, mas. *a wave*, *a billow*), *of* or *belonging to a river*.

Fortis, is, e, adj. *strong*, *brave*, *gallant*.

Fortiter, adv. *courageously;* comp. er, ius, issime.

Fortĭtūdo, ĭnis, fem. *strength*, *the capability of enduring*, *courage*, *valour*.

Gloria, æ, *renown*, *fame*, *glory*.

Homo, ĭnis, com. gen. *a human being*, *a man*, *a person*.

Hūmānĭtas, ātis, fem. *kind feeling*, *politeness*, *refinement*.

Hūmānus, a, um, adj. (from hŏmo, ĭnis, mas. *or* fem. *a human being*), *becoming a man*, *humane*, *kind*. Compare vir, i, mas. *a man*, *a hero;* virtus, ūtis, fem. *manliness*, *valour*, *moral excellence*.

Imperator, ōris, mas. *a commander-in-chief*.

Imperātum, i, neut. *a command*, *that which is ordered*.

Impĕrium, i, neut. (from impĕro, āvi, ātum, āre, trans. with dat. *to command*, *to enjoin;* with acc. and dat. *to demand from*), *military power*, *command*, *dominion*.

Indūco, duxi, ductum, ducĕre (in *and* duco), *to lead into*, *incite*.

Infero, tuli, latum, ferre, verb active (in *and* ferro, *to carry*), *to bring in* or *against*, *assign*, *allege*.

Jūra, æ, mas. *Mount Jura*.

Jus, jūris, neut. *right*, *justice*, *privileges;* hence jusjurandum, gen. jurisjurandi, neut. *an oath*.

Lăcus, ūs, *a lake*, *a sheet of water*, larger than a pond, and which does not dry up.

Latē, adv. (latus, *broad*), *widely;* latius, latissime.

Lātus, a, um, adj. *broad;* hence lātĭtūdo, dĭnis, *breadth*. Distinct from lătus, tĕris, *the side*.

Lĕmannus, i, mas. *the Lake of Geneva*.

Lŏcus, i, *place*, *situation*, *position;* plur. loca, neut. [except to signify places or passages in a book, heads of discourse, or the lines or surfaces traversed by a point, when *loci* is used].

Longe, adv. (longus, a, um), *far off*, *by far;* longius, longissime.

Longĭtūdo, dĭnis (longus, *long*), *length*.

Magnus, a, um, adj. (major, maximus), *large*, *great*.

Marcus, a proper name (*prænomen*) signifying a crushing thing, *e.g.* a large hammer.

Messāla, æ, mas. Marcus Valerius Messāla Niger, a Roman consul.

Mille, num. adj. indecl. in sing., in plur. a noun (millia, ium), *a thousand*.

Minus, comp. adverbial neuter of parvus, minor, minimus, *less* (minus posse, *to be quite unable*).

Multitudo, dinis (multus, *many*), *a great number*, *multitude*.

Nātūra, æ (nascor, nātus, nasci, for gnascor, depon. intrans. *to be born*, *to arise*), *that which one has by birth or origin*, *the fixed qualities of a thing*, *nature*.

Nŏbĭlis, is, e, adj. *that may be known; distinguished*, *noble*.

Nŏbĭlĭtas, ātis (nōbĭlis), *nobleness; the nobility*.

Octo, indecl. num. adj. *eight*.

Octogēsimus, a, um, adj. *the eightieth*.

Octogies, adv. *eighty times*.

Octōginta, indecl. num. adj. *eighty* [LXXX.]

Orgĕtŏrix, īgis, *Orgetorix* (*i.e.* lord of a hundred hills), the chief of the Helvetii.

Passus, ūs (from pando, di, pansum and passum, dĕre, trans. *to spread out*, *to open;* hence passim, adv. *at random*, *everywhere*), *a step*, *a pace;* the stretch of the legs in walking, equal to 5 Roman feet; each Roman foot equalled 10·02 inches.

Păteo, ui, —, ēre, verb neut. *to be* or *lie open*, *extend*.

Perfacile (per and facile), adv. *very easily* or *willingly*.

Persuādeo, āsi, āsum, dēre (per and suadeo, āsi, āsum, dēre, *to recommend*), *to advise thoroughly* or *persuade*, *to convince*. The Romans said *suadere rem homini*, to recommend a thing to a person; we say, to persuade a person to a thing.

Piso, onis. Marcus Calphurnius Piso, commonly called M. Pūpius Piso, because adopted by M. Pupius. He was, through the influence of Pompey, chosen consul B.C. 61.

Possum, pŏtui, —, posse, verb neut. irreg. (potis and sum), *to be able*, *to have power* [to do something].

Pŏtens, tis, adj. *able*, *powerful*.

Potentia, æ, fem. *power*, *might*, *physical energy*.

Potestas, ātis, fem. *power*, *authority*, *moral influence*.

Pŏtior, ītus, īri, verb depon. (potis, *powerful*), *to become powerful over*, *attain mastery*, *acquire*.

Pŏtis, is, e, adj. *able*.

Præsto, iti, ĭtum *or* ātum, āre, intrans. (from præ and sto), *to stand before*, *to be superior;* trans. *to excel*, *to be responsible for*, *to maintain*, *to fulfil*, *to discharge*, *to display*, *to show*.

Prō (prŏ in some compounds), prep. *before*, *in front of*, *in defence of*, *instead of*, *for*, *in exchange for*, *in comparison with*, *in proportion to*, *according to*, *on account of*.

Prōvincia, æ (pro and vinco, vīci, victum, ĕre, *to defeat in battle*, *to conquer*, *or* vincio, vinxi, vinctum, īre, *to bind*), *territory* [held as conquered *or* bound], *a dependent state*, *a province*.

Quadrāgēni, æ, a, adj. *forty*, *forty each*. Compare quadringenti, æ, a, adj. *four hundred*, and quadringēni, æ, a, adj. *four hundred each* (from quatuor and centum).

Quadrāgēsimus, a, um, ord. num. adj., *the fortieth*.

Quadrāginta, indecl. num. adj. *forty* [XL.]

Regnum, i, neut. (rĕgo, *to rule*), *sovereignty*, *supreme power*, *kingdom*.

Res, rei, fem. (reor, *I think*), *a thing* (thought of). This word is used with great latitude and much variety of signification; *e.g.* account, advantage, affair, benefit, case, cause, circumstance, condition, event, interest, matter, property, reason, substance, &c.

Rhodanus, i, mas. (swift flow-er), *the Rhone*, a river in Gaul.

Se, acc. and abl. of sui [often reduplicated *sese*].

Sēquăni *or* Sĕquăni, ōrum, *the Sequans*, *the Sequani*.

Suus, a, um (sui), poss. adj. *belonging to the agent*, *his own*, *her own*, *its own*.

Totus, a, um (gen. ius), *all*, *the whole* (of a thing).

Undique, adv. (unde *and* que) *from all quarters*, *on every side*.

Ut, ŭti, conj. *that*, *in order that;* adv. *how*, *as*, *as soon as*.

Văgor, ātus, āri, depon. intrans. (from văgus, a, um, adj. *roving*, *roaming*, *wavering*, *shifting*), *to wander*, *to stroll*, *to ramble*, *to roam*, *to patrol*.

Section IV.—Analytical Translation and Imitative Composition.

1. Orgetorix fuit nobilis—Orgetorix was renowned. Orgetorix fuit ditis—Orgetorix was wealthy. Orgetorix fuit nobilissimus [homo]—Orgetorix was a most noble [man]. Orgetorix fuit [homo] ditissimus—Orgetorix was a most wealthy [man]. Orgetorix fuit longe nobilissimus et ditissimus—Orgetorix was by far the most noble and wealthy [man]. Orgetorix fuit longe nobilissimus et ditissimus Helvetiorum—Orgetorix was by far the most noble and wealthy of the Helvetii. Apud Helvetios longe nobilissimus et ditissimus fuit Orgetorix—Among the Helvetians by far the most famous and wealthy [man] was Orgetorix. 2. Is [*i.e.* Orgetorix] conjurationem facit—This [man] makes a conspiracy. Is conjurationem fecit—He made a conspiracy. Is conjurationem nobilitatis fecit—He made a conspiracy of the [whole body of the] nobility. Is conjurationem Helvetiorum nobilitatis fecit—He made a conspiracy of the nobles of the Helvetians. Marco Messala (existente) consule—Marcus Messala being consul. [The Roman method of indicating (1) *the time when* anything which is referred to happened; (2) *how long* it was *since* a circumstance occurred, or *within what time* anything may be calculated as having taken place, was to put the words stating the time in the ablative case, with a participle either expressed or understood; and this sentence therefore signifies, When Marcus Messala was consul.] Marco Pisone consule—When Marcus Piso was consul. M. Messala et M. Pisone consulibus [in such phrases as this the conjunction *et* is sel-

dom used]—During the consulship of Marcus Messala and Marcus Piso (*i.e.* in A.U.C. 93 or B.C. 61, in which year Cæsar was quæstor in Spain). Is regni cupiditate est inductus—He (*i.e.* Orgetorix) was incited by a passionate desire of royal rule. Is M. Messala et M. Pisone coss. [contraction for consulibus] regni cupiditate inductus, conjuriationem nobilitatis fecit—He, during the consulship of Marcus Messala and Marcus Piso, incited by an ambition for dominion, excited a conspiracy among the nobles. 3. Orgetorix suadet—Orgetorix recommends. Orgetorix persuadit civitati—Orgetorix succeeds in recommending (*i.e.* induces) the entire body of the citizens. Illi eunt—They go. Exeunt—They go out, depart. De finibus suis exeunt—They go out of their own territories. Orgetorix persuasit civitati ut de finibus suis exirent—Orgetorix recommended to the citizens that they should depart from their own territories. [*Ut*, with the imperfect subjunctive *exirent*, is used for "to depart," as an infinitive of purpose. A purpose is not expressed, as it is *now* in English, by the infinitive, but by (1) *qui* and a subjunctive; (2) *ut*, or some similar conjunction, and a subjunctive; (3) the supine; (4) the future participle; (5) the gerund; (6) the gerundive—*i.e.* the future participle passive; or (7) an adverbial phrase, *e.g.* *causâ*, *gratiâ*, &c., with a noun, &c., in the genitive case.] Orgetorix civitati persuasit, ut de finibus suis, cum omnibus copiis, exirent—Orgetorix recommended to the citizens that they should depart from their own territories with all their forces (possessions, belongings, &c.) Facile est—It is easy. Perfacile est—It is very easy. Perfacile erat—It was very easy. Imperio potiuntur—They possess dominion. Perfacile erat imperio potiri—It was a very easy matter to seize the supreme power. Perfacile erat totius Galliæ imperio potiri—It was a very easy matter to seize the supreme power of the whole of Gallia. Illi stant—They stand. Præstant—They stand before (*i.e.* in the forefront). Omnibus præstant—They are superior to all. Virtute omnibus præstabant—In valour they excelled all. Perfacile erat, quum virtute omnibus præstarent, totius Galliæ imperio potiri—It was a very easy thing, seeing that in valour they excelled all [others], to obtain the dominion of all Gallia. [*Quum*, as a causal conjunction, is followed by the subjunctive; *præstarent* is put in the imperfect or past tense because Cæsar imports into the expression of Orgetorix (the speaker) his own idea—as an actor in and writer regarding these events—that the pre-eminence asserted is gone.] Perfacile esse [Orgetorix dixit, ostendit, persuasit]—[Orgetorix said, showed, induced them to think] that it was very easy. (*Persuadeo* is an active verb usually governing the dative, and it has been so used in this sentence in regard to *civitati* as a body of persons; but it may also take, besides the dative of a person, the accusative of a thing. To avoid, however, the complication of the sentence by this double government, it is most usual to regard *perfacile esse* as an infinitive governed by some active verb—such as *dico*, *ostendo*, &c.—whose meaning is contained in *persuadeo*, I bring over, by talking to them.) Civitati persuasit, ut de finibus suis, cum omnibus copiis, exirent [dixitque] perfacile esse—quum virtute omnibus præstarent—totius Galliæ imperio portiri—He prevailed on the citizens, that they should leave their own territories, with all their possessions, [and said] that it was a very easy matter—since they were more valiant than all the others—to secure supreme power over the whole of Gallia. Id eis suadet—He recommends to them this [object]. Id eis persuasit—He succeeded in recommending this to them. Id facile eis persuasit—He succeeded in recommending this to them easily. Id facilius eis persuasit—He succeeded in recommending this to them very easily. Id hoc facilius eis persuasit—He succeeded in recommending this to them very easily on this account. Id hoc facilius [quam aliter potuisset] eis persuasit—He succeeded in recommending this to them more easily [than he would otherwise have been able to do] on this account. (The phrase in brackets is the second member of the comparison involved in *facilius*. Though it is usually omitted both in English and Latin in similar sentences, it is right that its latent presence in the mind should be recognized.) Undique Helvetii continentur—The Helvetians are hemmed in on every side. Undique natura loci Helvetii continentur—The Helvetians are hemmed in on every side by the nature of the locality. Id hoc facilius eis persuasit quod undique natura loci Helvetii—(*Quod*, the accusative neuter singular of *qui*, *quæ*, *quod*, here signifies "because" or "inasmuch as," and is used as a conjunction in stating a fact). Helvetii una ex parte continentur flumine Rheno—The Helvetians on the one part are hemmed in by the river Rhine. Helvetii una ex parte continentur flumine Rheno latissimo—The Helvetians on the one part are hemmed in by the very wide river Rhine. Helvetii una ex parte continentur flumine Rheno altissimo—The Helvetians on the one part are hemmed in by the very deep river Rhine. Una ex parte continentur flumine Rheno latissimo atque altissimo—On the one part they are hemmed in by the very wide and [*or* as well as] very deep river Rhine. Helvetii altera ex parte continentur Jura—The Helvetians are hemmed in on another part by Jura. Altera ex parte continentur Monte Jura—Are hemmed in on another part by Mount Jura. Altera ex parte continentur Monte Jura altissimo—Are hemmed in on another part by the very lofty mountain range of Jura (which stretches in several parallel chains about 190 miles from S.S.W. to N.N.E. The Rhone cuts its way through the southern portion, where it links on to the Savoy Alps, and the northern portion of the range meets the high ridges of Aargau and the Böhmer Wald. Many of the peaks of Jura reach a height of 4000 feet. Mont Moléson is 6600 feet). Tertia ex parte continentur lacu—On the third part they are hemmed in by a lake. Tertia ex parte continentur lacu Lemanno—On the third part they are hemmed in by Lake Leman (the largest Swiss lake, at the western extremity of which stands the town of Geneva. It is crescent-shaped, 50 miles long, 6 broad, 1150 feet above the sea-level, and 150 fathoms deep). Tertia ex parte continentur lacu Lemanno et flumine Rhodano—On the third part they are hemmed in by Lake Leman and the river Rhone. Flumen Rhenus agrum Helvetium a Germanis dividit—The river Rhine divides the Helvetian territory from the Germans. Mons Jura est inter Sequanos et Helvetios—The Jura range is between the Sequani and the Helvetii. Flumen Rhodanus provinciam nostram ab Helvetiis dividit—The river Rhone divides our (*i.e.* the Roman) province from the Helvetians. Helvetii late vagantur—The Helvetians wander widely. Minus vagantur—They wander less [than they wished]. Fit ut vagentur—It happens that they wander. Fit ut minus late vagentur—It happens that they wander less widely. His rebus fiebat ut minus late vagarentur—By these circumstances it came about that they could wander less widely than they wished (*or* could not wander so widely as they wished). Bellum inferunt—They carry on war. Bellum inferre possunt—They are able to (*i.e.* can) carry on war. Bellum finitimis inferre possunt—They are able to carry on war on neighbouring [people]. Minus facile bellum finitimis inferre possunt—They are able to carry on war less easily on neighbouring [people]. His rebus fit ut minus facile bellum finitimis inferre possint—By these circumstances it is brought about that they can less easily carry on war on neighbouring [people]. His rebus fiebat ut minus facile bellum finitimis inferre possent—By these circumstances it was brought about that they could less easily carry on war on neighbouring [people]. His rebus fiebat, ut et minus late vagarentur et minus facile finitimis bellum inferre possent—In consequence of the circumstances referred to, it came about that they both wandered about less widely [within their own boundaries, at peace] and [in war] could less easily attack their neighbours.

Helvetii magno dolore afficiuntur—The Helvetians are stricken with great grief. Helvetii sunt homines bellandi cupidi—The Helvetians are men fond of fighting. Homines bellandi cupidi magno dolore afficiebantur—Men fond of fighting were stricken with great grief. Qua de causa homines bellandi cupidi magno dolore afficiebantur—For which reason men fond of fighting were stricken with great grief. Angustos habent fines—They have narrow boundaries. Angustos habebant fines—They had narrow territories.. Pro multitudine hominum angustos habebant fines—In proportion to the multitude of (their) inhabitants they had confined limits. Pro gloria belli angustos habebant fines—In proportion to their renown in war they had confined limits. Pro gloria fortitudinis angustos habebant fines—In proportion to their renown for courage they had confined limits. Angustos se

fines habere arbitrantur—They think that they had straitened territories. Angustos se fines habere arbitrabantur—They thought that they had straitened territories. Pro multitudine autem hominum, et pro gloria belli atque fortitudinis, angustos se fines habere arbitrabantur. But (or moreover) they thought that they, in proportion to the largeness of their population, and considering their warlike renown and bravery, had straitened confines. [Cæsar informs us in Chapter xxix. that in the Helvetian camp a register was found of all those who had departed from their homes, arranged according to their tribes, and that the sum-total of the emigrants amounted to 368,000, of whom 92,000 were able to bear arms.]

Hi [fines] millia passuum ducenta patent—These territories extend two hundred thousands of passes—200 miles. Hi millia passuum CC patebant—These extended 200 miles. Hi millia passuum ducenta quadraginta patebant—These extended two hundred and forty miles. Hi in longitudinem millia passuum CCXL patebant—These in length extended to two hundred and forty miles. Hi in latitudinem centum octoginta (CLXXX) patebant—These in breadth extended one hundred and eighty miles. [Had this been an expression of the thoughts of the Helvetii narrated by Cæsar, the verb would have been in the subjunctive, qui paterent. The use of the indicative shows that this is really a parenthesis of Cæsar's, dropped concessively, as if he had said, "Now these territories, of which the Helvetii complained, did indeed only extend to," &c. The following extract from Froude bears so close a relation to this passage that it will help us to understand it better:—"The Helvetii were old enemies; on them, too, the tide of migration from the north had pressed continuously. They had hitherto defended themselves successfully, but they were growing weary of those constant efforts. Their numbers were increasing, and their narrow valleys were too strait for them. They also had heard of fertile, scantily peopled lands in other parts, of which they could possess themselves by force or treaty, and they had already shown signs of weariness." *Cæsar*, p. 201.]

Section V.—Complete Version of the Foregoing Latin Text.

Orgetorix was, by far, the most distinguished and wealthy person among the Helvetii. This man (just spoken of), in the consulship of Marcus Messala and Marcus Piso [B.C. 61], incited by a passionate desire for the possession of regal power, entered into a compact with the nobility, and persuaded the entire body of the citizens that they should remove from their [restricted] territories, pointing out to them that it was a very easy thing for them, because that in valour they were superior to all [others], to make themselves masters of the whole of Gallia. To this he [all] the more easily persuaded them, because by the [very] nature of their situation the Helvetii are hemmed in on every side: (1) on the one hand, by the very wide and deep river Rhine, which divides the Helvetian land from the Germani; (2) on the other hand, by the very lofty mountain-range (of) Jura, which is between the Sequani and the Helvetii; and (3) in the third place [*tertia ex parte*] by Lake Leman (Geneva), and the river Rhone, which divides our [*i.e.* the Roman] province from the Helvetii. In consequence of these circumstances it happened that they could the less widely wander [in their own possessions], and also were less easily able to carry war into the neighbouring territories. For which reason [or, as some read, in which respect] these men, fired with the desire of fighting, were stricken with great sorrow (or dissatisfaction). Moreover, they thought that in proportion to the large number of their people, and in consideration of their renown in war and for bravery, they had boundaries far too confined, which stretched two hundred and forty miles [the Roman mile being eight stadia, each of which consisted of 125 passūs, the entire mile equal to 1611 yards 4 inches] in length, and one hundred and eighty miles in breadth.

PHYSIOLOGY.—CHAPTER X.

THE MECHANICS OF THE HUMAN FRAME—JOINTS—MOTION AND LOCOMOTION—EXERCISE.

Before proceeding to show the interrelations of respiration, digestion, circulation, assimilation, nutrition, work, exercise, &c., and their results in secretion, evolution of force, excretion, exhalation, &c., it will be found useful to revert, in a few pages, to the mechanics of the human frame, in supplement of the contents of Chapter I. on the general build of the skeleton, exhibited tabularly in p. 50, illustrated in Plates I. I.A, and II. II.A, and described pp. 46–50. In the case of muscles mentioned as organs of motion or of locomotion, reference may frequently be required to Chapters III. and IV. (pp. 132–136 and 224–227, with their illustrative Plates V. and V.A) for particulars of integral structure, origin, and course, which may be omitted in the present chapter as not directly involved in the elucidation of the special point at present taken in hand, which is the articulation of bones, more particularly as means for accomplishing motion and locomotion, that is, less considered as joinings than joints.

Bones are at once hard and tough. They form the main framework of the body, they supply protecting cases for important organs, and they act as levers by which locomotion is performed and force is exerted. As might be expected in a machine so complex as the skeleton, bones assume a great variety of shapes. If the reader will turn to Plate IV. he will see this statement made sufficiently plain to his own eyes. In regard to shape, bones may be considered as forming four classes, (1) *long* or cylindrical, like those of the extremities, meant for sustaining weight and adapted for movement: they are never exactly cylindrical, but narrow towards the middle of their length, and become enlarged at their ends so as to fit them better for such articulations as are requisite; (2) *flat* or broad, and usually arched, such as the bones forming the cranium: these are generally intended to afford protection; (3) *short* and *round*, such as are found in the wrist and instep; and (4) *mixed* or irregular: those which combine some two of the characters of the previous classes. The bones of the spine, for instance, long in their cylindrical form and short in their roundness, and the ribs, the pelvis, &c., are examples of bones at once long and flat. See Plate IV. for illustrations of all these, in carefully arranged groups.

The outer portion of a bone is much harder and more firmly textured than the inner part; hence the former is called the *compact* or *condensed*, the latter the *cellular* (*i.e.* spongy) or *cancellated* substance. These tissues are arranged differently in the different classes of bones. The surface of bones is sometimes rough, to afford attachments for the softer tissues; sometimes smooth, to allow the free play of those softer tissues over them. Some have hollows, in which muscles may be inserted or other organs placed; others have grooves, in which tendons may run or blood-vessels lie. Articular surfaces are rough, if the joint is to be wholly or in great measure *synarthrose* (*i.e.* without movement at the point of union), and smooth if they are to be *diarthrose* (*i.e.* movable at the place where the parts join). Processes or projecting points occur on them where particular fibres, muscular or ligamentous, are to be attached to them.

(1) The long bones consist of three parts—a shaft and two extremities. The shaft consists of very dense compact tissue externally, becoming loose internally, and having a canal running through it nearly from end to end. Their extremities are of the same structure as the short bones. This canal makes the bone, with the same quantity of material, much stronger than if it were solid, because its diameter is much greater. This principle is understood and acted on by engineers, who make pillars and shafts hollow, in order that, without increased expense of metal, they may gain additional strength. In this way substance, weight, and muscular force are each economized, and yet the maximum of solidity and mobility are attained.

The canal which thus runs through the long bones is lined with a delicate membrane, in which is contained the medulla or marrow. Hence it is called the medullary canal. The medulla, being fatty matter, is the lightest that could be used for filling the space, and serves, as the fat in other parts of the body does, as a store of nourishment whence the body can be supported when unable to take any nourishment from without.

(2) The flat bones have their compact substance arranged

into two dense layers, separated by a thin intertissue of cancellated structure, through which the bloodvessels which nourish the bone run. When the bone is very thin, the two outer layers are in contact, or appear compressed into one, and this intermediate layer does not, as in the diploë of the bones of the skull, appear.

(3) The round bones have a very thin layer of compact tissue on the outside, while the internal part is composed of cancellated tissue. In consequence of this predominance of cellular tissue, and consequently of bloodvessels, the round bones are much more liable to inflammatory and carious affections than any of the others.

(4) The irregular bones, resembling in shape two or more of the preceding orders, have some of their parts, generally their bodies, like the round bones; and others, the processes, resembling the long and flat ones.

Bones are covered by a dense, highly vascular, tough, fibrous membrane called the periosteum (Gr. *peri*, around; and *osteon*, a bone), which adheres strongly to them, serves to convey the bloodvessels to them, and sends prolongations into all the little holes which exist in great number on their surfaces. It acts also as the medium for the attachment of tendons and ligaments to bones, having those parts in a manner interwoven and combined with its outer surface. The periosteum has also the chief part to perform in the formation and growth of bones, and in the reparation of old ones, when fractures or other injuries have rendered that necessary. It also serves to isolate bones from their surrounding structures, and so prevents the spread of disease from these tissues to them.

As bones are vital component parts of the human frame, they must be formed and nourished. Bones are largely supplied with bloodvessels, and the periosteum is the means by which they receive nutrition. The medullary membrane, or internal periosteum, is supplied by a special artery for the nourishment of the compact tissue. It enters a bone generally rather above than below the middle, divides into two branches, one of which runs up and the other down, separating into smaller sub-branches as they proceed, and by anastomosis (*i.e.* mouth-to-mouth union) join the arteries which the external periosteum had brought to the cancellated tissues. In these tissues the arteries run in small capillary canals too minute to be visible to the naked eye, which, after their discoverer, Clopton Havers, are called the Haversian system. Nerves can be seen entering bones, but neither their presence nor that of absorbents have been, as yet, demonstrated as forming a part of the osseus tissues.

When bones touch one another, and are movable, they are particularly smooth, and their surfaces are adapted to one another by finely corresponding prominences and concavities. To obviate friction they are covered at those places where they join with what is called gristle or cartilage. Cartilage is a substance of pearly purity in appearance, intermediate in hardness to bone and what are commonly called the softer parts. It is uniform and homogeneous in structure, and firm and resisting, though possessing a great deal of elasticity. It is much softer than bone, but harder than any other of the soft parts; it is highly elastic, and, if compressed or bent, speedily regains its original shape. In some parts of the body there are cartilages serving for continuations to bones, such as those which continue the ribs and connect them to the breastbone, and they are exactly similar in their elements to bones from which the earthy part has been dissolved by an acid. The cartilage which covers the articular ends of bones is of a very beautiful and peculiar structure. It presents, on inspection under the microscope, an infinity of filamentous fibres set perpendicularly on the surface of the bone, like the pile of an exceedingly fine white velvet. Owing to this special characteristic, when pressure is made on the ends of these fibres, they yield by bending a little sideways, but are prevented from yielding too much because of the closeness with which they are set together. Thus they allow rather of indentation than compression.

The bones composing the human skeleton are articulated or joined to one another in three different ways—(1) dovetailed into one another, with the intervention of a very thin layer of cartilage, and quite immovable; (2) connected by layers of cartilage between them, and ligaments or fibrous bands on their outsides, tying them together, admitting of more or less motion; (3) united by cartilages, ligaments, and synovial membranes, such united apparatus forming the most perfect joints—those, for instance, which are found between the bones of the extremities.

The joinings of the bones of the cranium are called *sutures*, from a Latin word signifying to sew, because they seem as if cross-stitched together. The fibres of the one bone form prolongations which pass into the notches or spaces left by the similar prolongations of the other, as is seen in the figure of the skull already given at p. 47. Between these there runs a thin layer of cartilage. These sutures, as seen in the drawing, run in determinate lines over the head, but in a work intended for popular reading it would be out of place to give a more detailed description of the cranium than is contained on the page to which reference has been made.

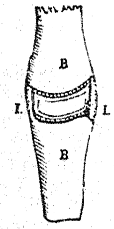
The bones of the spine are united, each to each, by thick layers of a peculiar fibrous cartilage, mixed with ligaments, placed between them, so as to act like a buffer for the prevention of jars or shocks, by admitting of but little motion between any pair of vertebrae, though allowing considerable curvatures to take place in the whole length of the spine. This arrangement is obviously intended to make sure that the spinal marrow which is contained in the canal formed by the contiguous rings of the twenty-four vertebræ, may not be subjected to any injurious pressure or twisting at any single point. Strong ligaments also pass down along the spine in front and behind, binding its different pieces together into one strong, elastic, slightly curvilinear column, singularly flexible and various in power of movement.

Ligaments (Lat. *ligamentum*, a bandage), it should perhaps have been previously stated, are white membranous felted tissues, composed of numerous straight fibres collected together, and arranged into short bands of varying breadths, parallel or radiating, interwoven with others which cross them, so that they cannot be split up into threads. Anatomists arrange ligaments into three classes—viz. (1) *funicular*, rounded twine-like cords—*e.g.* the outer lateral ligament of the knee and the perpendicular ligament of the ankle; (2) *fascicular*, flat, broad bands of tissue felted together into swathes, such as most of the ligaments in the body are—*e.g.* the lateral ligaments of the elbow-joint; and (3) *capsular*, so formed as to surround and invest the articular ends of two bones which move upon one another. They are the ligaments most used in ball-and-socket joints—*e.g.* the shoulder-joint, the hip-joint, &c. Ligaments are neither extensible nor elastic. Hence, when any attempt is made or any accident occurs to stretch them too far, great pain is the result, inflammation follows, and they are said to be *sprained*. If the force applied be very great, they may even be entirely ruptured. Ligaments, while they freely allow of some movements of the bones which they unite, limit or prevent others.

The different parts of the pelvis are united by means of cartilage and ligaments, each bone having its articular surface covered with cartilage. These are laid together, with or without the intervention of a third layer, and are bound firmly by ligaments passing over them. Such are the joints between the two haunch-bones, and between them and the rump-bone.

The joints of the extremities are of a more complicated nature. The ends of the bones entering into these joints—having their forms adapted to one another—are covered with cartilage, then they are tied together by ligaments; and, in addition, a membrane, called *synovial*, is spread over the ends of the bones and lines the ligaments, forming a shut bag, whose inner surfaces are everywhere in contact, and these, to obviate friction, are moistened with a bland mucilaginous fluid, called *synovia*. The synovial membrane has a smooth velvety surface, like that of the membrane which lines the mouth and nose. The fluid which collects in the articular cavities of the joints, does not, in reality, contain any oil, yet it has very much the feeling of oil when rubbed between the fingers. It is an alkaline slightly yellowish mixture, something between serum and mucus. When it increases too much in quantity it produces various painful affections of the joints.

The figure in the margin is a plan of a finger joint, one of the simplest of the perfect joints. B B are the two bones; L L, the two side ligaments (which may be felt at the sides of the finger), tying together those parts of the two bones between which there is the least motion. The cartilages are seen marked by cross lines, covering the ends of the bones, and inside of these the synovial membrane is shown, lining both them and the ligaments. A space is represented within the joint, merely for the sake of making its component parts plainer; but, in reality, there is no space or cavity within a joint, all the surfaces being in close, air-tight, articular contact.



These coatings of cartilage which line the surfaces of the joints are called articular cartilage. They prevent any of that jarring which might result were the hard surfaces of bones to be brought with violence immediately into contact one with another.

The motions permitted in joints may be referred to four heads—viz. (1) gliding, (2) flexion and extension, (3) circumduction, and (4) rotation. (1) *Gliding* is the simple movement of one articular surface upon another, and exists to a greater or less extent in all the joints. In the least movable joints—*e.g.* those of the solid parts of the hands and feet—this is the only motion for which arrangements have been made. (2) *Flexion* and *extension*—*i.e.* angular movement—is most simply seen in the joints of the fingers, where no other motion is provided for but those of flexion and extension. At the joint between the metacarpal bone and the first bone of the finger, both *adduction* and *abduction* are possible; that is, approaching to or removing from its next neighbour. (3) *Circumduction* consists in the performance of these four motions consecutively—flexion, abduction, extension, adduction—as is seen in making the point of the fore-finger describe a circle, having the metacarpal joint for its centre. (4) *Rotation* is the rolling of a bone upon its own axis, as seen (1) in the hip and shoulder joints, (2) the upper end of the radius in pronation and supination of the hand, and (3) the articulation between the first and second vertebræ of the neck, when the head is turned shortly round from side to side.

The head is set upon the first vertebra of the neck, through the medium of a couple of joints admitting of flexion and extension only. When a quick short nod of the head is given, the motion made takes place here. The first vertebra of the neck is a circle moving round a pin projecting from the second vertebra—thence called the *axis*—carrying the head round with it, in the quick short movement of looking from side to side. The only complete dislocation that takes place in the spine is at this joint, in consequence of the destruction of the ligament which keeps these bones in their places.

The lower jaw—which is the only bone of the head requiring to have any means of movement provided for it—is connected with the temporal bone by a joint which is almost completely a hinge one. The upper knobbed end or *condyle* of the jaw-bone is covered with cartilage, so is the socket, and the two bones are tied together by side ligaments. There is, besides, a movable cartilage in the joint which accompanies the condyle of the jaw in its motion. Notwithstanding all these precautionary appliances, the jaw is sometimes dislocated, slipping forward off the eminence upon which it gets when the mouth is opened. This dislocation, when it has once happened, is exceedingly liable to be reproduced, in consequence of the torn ligaments never properly re-uniting.

Strong bands of fibre tie the collar-bone to a slight hollow in the upper corner of the breast-bone; the motion is very free, and to render it even more so, a movable cartilage is interposed between them. This joint is very rarely injured—indeed, in consequence of being so well secured at both ends, the collar-bone is much more frequently broken than dislocated. The collar-bone and the shoulder-blade are very firmly bound together, so as to move, as it were, in one piece; yet a slight yielding is permitted, otherwise, as they stand at right angles to one another, fracture or dislocation about this joint would much more frequently occur. This union of the collar-bone (or clavicle) with the upper end of the sternum, by the articulation of the outer end of the clavicle with the scapula, and this combination of articulated bones, form what is called the shoulder-girdle. The shoulder-joint is of all others the most frequently dislocated. This results partly from its form, and partly from its being more exposed to violence—since every fall, whether upon the shoulder, arm, or hand, has a tendency to displace it. The cavity of the shoulder-blade is so small and shallow, that the round head of the arm-bone is laid not *in* but *on* it. Its barrel-shaped capsular ligament is strong, but loose; so that the bone depends, for being retained in its place, upon the muscles which surround it. If these be overcome or taken by surprise, particularly when the arm is raised, the head of the bone is dislocated down into the arm-pit. It is, in general, replaced without much difficulty, but is exceedingly liable to be thrown out again. The shoulder-joint admits of greater freedom of motion than any other in the body; this arises from the smallness of the scapular surface when compared with the globular surface of the head of the *humerus* which moves on it.

The elbow-joint is more complex than the shoulder one. It is double in its motions, admitting not only of the flexion and extension of the forearm on the arm, but also the rolling of the head of the radius. For the former motion it has two strong lateral ligaments, which may be felt at the two sides, rendering it a hinge-joint; and for the latter, the neck of the radius is confined to the side of the ulna by a collar in which it rolls. A synovial membrane covers the ends of the bones, and lines the different ligaments. It may be dislocated in many directions. Both bones of the forearm are, most commonly, thrown backward, as in a fall on the hand; then the arm is nearly straight, and cannot be bent. Sometimes the forearm is thrown sideways, either outward or inward, and at other times the radius is dislocated alone—backwards, forwards, or outwards.

The wrist is a hinge-joint, moving backwards and forwards, and also allowing the hand to be carried a little edgewise, outwards, or inwards. The lower end of the radius forms a socket in which the uppermost two bones of the wrist move, so united as to form an oblong ball. Two lateral ligaments confine the hand to the lower ends of the radius and ulna, and the whole joint is lined by synovial membrane. This joint is, though rarely dislocated, very liable to sprains.

Closely connected with the wrist-joint, although not actually forming a part of it, is the joint between the lower ends of the radius and ulna. Here there is a socket in the edge of the radius; this is made to revolve round the small lower end of the ulna, which remains fixed, while the hand is thrown, alternately with its palm and its back, forwards.

The bones of the hand are seldom subject to dislocations, except at the joint between the first and second pieces of the thumb. Such an accident, though seemingly trifling, is extremely difficult to set to rights.

The hip-joint consists of a deep socket in the haunch-bone, into which the round ball-like head of the thigh-bone is set. A capsular ligament, of great strength, of a barrel-shape, attached round the edge of the socket and to the neck of the bone, fixes it in its place. The opposed surfaces of the bones are covered with cartilage and are tied together by an internal ligament, which, though in reality triangular rather than round, receives the anatomical designation of *ligamentum teres*, the rounded ligament. It has its apex fixed to the head of the thigh-bone, while its base is attached to the acetabulum or cup. Its most probable use is to limit the freedom of motion, and to make any superincumbent weight rather swing off than press on the thigh-bone. The whole is lined with a synovial membrane. This joint, notwithstanding its strength, surrounded as it is by a large number of muscles of considerable power, is subject to dislocation, principally on account of the long lever which the thigh-bone affords to any force acting upon it, so as to tear the head from its socket.

The knee is the most complicated joint in the whole body. The ends of the thigh-bone and *tibia* are each covered with cartilage, and in contact; neither of them, however, is hollowed—so that the joint does not depend for strength on its form, but on the number and strength of its ligaments. Two of these are placed externally and internally—as in all hinge-

joints—and seven others are arranged, in different positions, within and without it. The knee-cap—a *sesmoid* bone, not forming a portion of the skeleton—is placed in front of it, and the whole is lined with a synovial membrane, which is the largest in the body; hence the fever and extreme constitutional disturbance that arise when this joint becomes inflamed. It lies very superficial, being covered only by the skin in the greatest part of its extent; hence it is very easily wounded by a cut or puncture from any sharp instrument. It is scarcely ever dislocated, owing to the number and strenth of the ligaments which invest and protect it.

The ankle is a hinge-joint, having one lateral ligament on its inner, and three on its outer side. The upper surface of the *astragalus* is like the half of a broad pulley; it plays against the lower hollow end of the *tibia*, and is received between the two ankles formed by it and the *fibula*. This part of the *astragalus* is narrower behind than in front, so that when the foot is at right angles to the leg, as we stand on it, the broad part is between the ankles, and it is firmly fixed; but when the foot is extended, pointed downward, the narrow part is brought between them, so as to admit of the toes being directed to either side. The ankle-joint may be dislocated forwards, or to either side. Its ligaments are so strong that the bone will break sooner than they give way. Simple dislocation of the ankle can scarcely ever take place without a wound coexisting.

A *simple dislocation* is one where the bones are displaced, but the joint is not laid open; a *compound* is not more serious in so far as the bones are concerned, but is accompanied with a wound in the muscular surroundings of the joint. A *simple fracture* is when a bone is broken without a wound; a *compound* one is where there is a wound communicating with the broken surfaces.

The joints across the foot are numerous, and not easily described in any popular way, as any language except that which is distinctly technical fails us in this case. There is one joint across the middle of the *tarsus*, or solid part of the foot, which, in some persons, admits of a good deal of lateral motion; and, in such feet, is liable to be sprained. Another joint runs across between the bones of the *tarsus* and those of the instep. The joints of the toes require nothing particular to be said of them—only that they are similar to those of the fingers, but much smaller.

Joints are (1) movable, (2) immovable. Of the latter sort there are two varieties—(1) sutural, like those of the bones of the cranium, and (2) inserted, as the teeth in the alveoli of the jaws—when teeth are regarded as bones and not as evolutions of the skin. Of the former the three main divisions are those of (1) hinge, (2) ball and socket, and (3) pivot. In the structure of movable joints we have presented to us (1) articular surfaces, those parts of the bones brought together which correspond to or are fitted for moving upon each other. (2) Articular cartilages, the smooth layers of gristle which form the coverings of the articular surfaces which, by their polish, pliability, and elasticity, prevent injurious friction, jar, or shock, yield when pressure is applied, and resume their ordinary condition when this is removed. (3) Articular ligaments, which bind the connected bones, and by clasping or surrounding them keep them in their places. They are (i) suspensory or inter-articular, (ii.) compressive or capsular, (iii.) lateral, and (iv.) crucial supports. A bone is technically said to be *flexed* when bent, *extended* when stretched out, *abducted* when moved from, and *adducted* when moved to another, *rotated* when turned round on its own axis, and *circumducted* when made to rotate round an imaginary action.

Hinge-joints are single, as the elbow, knee, and ankle, or double, as the thumb; in these the head of one bone fits into a socket in the other; ball-and-socket joints have a surface more or less rounded, playing in a sort of cup more or less deep. The shoulder is such a joint with a shallow, and the hip with a deep cup. Pivot-joints are those in which one bone forms the axis on which another turns, as in the *atlas* and *axis;* and one bone turns on its own axis resting on another bone, as in the forearm when the hand rotates while the elbow is still. The bones thus jointed are moved by the contraction and counteraction of the various muscles which assist or resist each other. The maintenance of an erect posture is the result of an accurately proportioned action and interaction of a vast number of muscles, and walking mainly depends on a definite and alternate interplay of the muscular powers by which one of the legs is made to poise the entire weight of the body while the other swings itself forward and then takes upon itself the duty of sustaining the frame, while the other performs the task of effecting progression.

Referring to NATURAL PHILOSOPHY (p. 212) for the scientific exposition of the lever, we may note here that, as a general rule, bones which are intended for ordinary use as levers have their osseous structures arranged in the form of a shaft. At least one end of these bony shafts possesses a smooth articular surface, protected by a cartilaginous sheath which enables it to play upon the corresponding surface of some other bone to which it is relatively fixed, and to which it is articulated, or enables that other bone to move on it. One of these related and appropriated ends forms the fulcrum while the other is being employed as a lever, and the contractile muscle attached exerts the power which produces the motion. Of levers of the *first* kind we may instance (1) the skull, when it is moved either backward or forward on the atlas as a fulcrum; (2) the pelvis, when it moves on either of the thigh-bones as a fulcrum; and (3) the foot, when it is raised or depressed, having the ankle as its fulcrum. Of the *second* sort are (1) the thigh-bone of the leg, when drawn up towards the body, as in the unused limb while hopping; (2) a rib depressed in expiration; and (3) the toes when resting on the ground, we raise the whole body on tiptoe, making the point of pressure the fulcrum, our body the weight, and the power the muscles from calf to heel. The *third* kind are typically exhibited in (1) the flexion of the forearm toward the arm, while holding a weight in the hand; (2) the holding out of the leg, extended from the thigh at the knee-joint; and (3) the upholding of the body, in an erect posture, upon the lower extremities while standing, walking, &c.

Taking the surface presented by the soles of the two feet when placed on the ground as the basis on which the body must be supported when standing, the cervical muscles are required to preserve the head erect. The columnar pile of the spine is maintained in an upright posture by the dorsal muscles. The legs, being a series of pieces set longitudinally upon each other, must be kept from bending under the weight of the body by the large masses of muscle which regulate the movements of the joints. The legs must also be kept perpendicular to the foot, and the other muscles must be retained in action in order that the proper poise and position of the person may be preserved.

The flexors and extensors, the adductors and abductors of the toes, are antagonist muscles; the flexors bend the toes downward; the extensors raise them upward; the adductors draw them inward. and the abductors outward. And much in the same manner the antagonists of the leg also act upon the foot, and move it by the ankle-joint in every possible direction. The mechanism of the leg and foot is beautiful and perfect, and nothing that science has invented can equal its beauty and utility. By the simple and combined action of bones and muscles, we climb, walk, run, leap, dance, &c., and yet, by the aid of the simple, combined, and harmonious muscular machinery we can move all our joints at pleasure, and travel from place to place with equal agility and ease.

The mechanism by which the human frame is enabled to perform the functions of motion and of locomotion is highly complicated. Its construction involves most exact organization. The moving powers, compacted so economically into such a symmetrical form, display wise and admirable contrivance. The situation of each part, and the relations of these one to another, in order that, on necessity arising, any part or number of parts may be set in motion readily, kept in motion steadily, and act together combinedly with accuracy and pleasantness, require no ordinary union of simplicity and complexity. Yet over and above this, we find the whole so arranged that it is augmented and improved by use, activity, and exertion, and that judiciously regulated bodily exercise conduces to health, happiness, and longevity.

BOOK-KEEPING.—CHAPTER IX.

TRANSACTIONS OF WILLIAM KING—

(Continued).

We continue the transactions of William King, and present the Cash Book relative to these two months. It should be the duty of the student (1) to notice which entries pass into it—ticking off each as he traces it to its destination; (2) to think carefully over the reason why it gets its place; and (3) to copy out in accurate form the Cash Book.

1898.	Jan.		£	s.	d.	£	s.	d.
C.B. 1	30	Paid Robert Wilson, Birmingham,				134	6	6
		Received from him Discount,				4	6	6
D.B. 1	"	Sold to Roderick Dhu,						
		1 hhd. whisky *ex* duty, 210 galls., at 9/ per gal.,	94	10	0			
		1 " port wine, 193 galls., at 27/, per gal.,	260	11	0			
						355	1	0
	"	Received from him Bill at 1 Month,				300	0	0
C.B. 1	31	Discounted Roderick Dhu's Bill,				300	0	0
		Discount charged thereon, 6 per cent.,				18	0	0
C.B. 1	"	Paid into National Bank,				282	0	0
C.B. 1	"	Drawn from National Bank,				110	0	0
C.B. 1	"	Paid to Peter Paterson, Glasgow,				110	4	1
	"	Received from him Discount,				0	4	1
I.B. 1	"	Bought from John Robertson, Jamaica Street,						
		400 yds. black cloth, at 9/3,	185	0	0			
		250 " " " 8/6,	106	5	0			
		100 " serge, " 4/3,	21	5	0			
	Feb.					312	10	0
	2	Sold to John Kerr, Glasgow, Cwts. qrs. lbs.						
		2 boxes soap, 2 2 14 at 32/ per cwt.,	4	4	0			
		1 chest green tea, 1 0 7 at 4/6 per lb.,	26	15	6			
		12 cheeses, 481 lbs. at 10*d.* per lb.,	20	0	10			
		12 hams, 182 lbs. at 9½*d.* per lb.,	7	4	1			
						58	4	5
	"	Received for goods sold on Commission for Scott & Co., Glasgow,				250	7	6
		Commission charged thereon at 10 per cent.,				25	0	9
	"	Paid Scott & Co., Glasgow,				225	6	9
	4	Bought goods for cash,				13	7	6
	"	Cash from Samuel Johnson to Account,				200	0	0
	5	Paid into National Bank,				150	0	0
	6	Bought from James Grierson, Princes Street, Cwts. qrs. lbs.						
		6 kits butter, 13 3 14 at 1/3,	90	17	6			
		2 boxes raisins, 0 2 21 at 5*d.*,	1	12	1			
		2 boxes currants, 1 2 7 at 4½*d.*,	3	5	7½			
						95	15	2½
	8	Sold to John Coutts, Glasgow,						
		27 lbs. sash line at 8½*d.*,	0	19	1½			
		315 yds. clothes rope at 1*d.*,	1	6	3			
		2 doz. new clothes posts at 4/6 each,	5	8	0			
						7	13	4½
	"	Sold to John Henderson, Princes Street,						
		18 pair Men's E.-S. boots at 17/6,	15	15	0			
		16 pair ladies' slippers at 4/3,	3	8	0			
						19	3	0
	"	Bought from D. Paterson, Leith,						
		2 tons cement at 38/,	3	16	0			
		20 bags at 1/,	1	0	0			
						4	16	0

1898	Feb.		£.	s.	d.	£.	s.	d.
	9	Sold goods for cash,				3	9	10
	11	Paid trade expenses,						
		Carriages,				0	8	6
		Gas account,				1	6	3
	"	Paid to James Grierson, Princes Street,				95	15	2½
	"	Received from him Discount,				0	15	2½
		Bought from J. Jobson, Leeds,						
		2 tons cut nails, at £9 5/,	18	10	0			
		2 kitchen ranges, " £8 2/6,	16	5	0			
						34	15	0
	12	Received from Jno. Reid, Edin.				25	2	9
		Received from him discount,				0	2	9
	"	Paid into National Bank,				25	0	0
	13	Received from John Coutts, Glasgow,				8	0	0
	"	Received from J. Kerr, Glasgow,				58	0	0
	"	Sold to Theodore Horne, London, goods as per invoice,				13	7	6
		Paid freight on invoice,				0	12	10
	15	Bought goods for cash,				54	3	2
	"	Drawn from National Bank,				54	0	0
	"	Bought from Robert Wilson, Birmingham,						
		4 lobby lamps, at £2 15/,	11	0	0			
		6 " " 3 0/,	18	0	0			
		10 scroll brackets, at 16/6,	8	5	0			
						37	5	0
	16	Sold to John Brown, Greenock, Cwts. qrs. lbs.						
		2 kits butter, 2 1 7, at 1/5,	18	6	11			
		4 chests tea, 1 0 14, at 3/2,	19	19	0			
		6 bottles Port wine, at 3/6,	1	1	0			
		3 " Sherry " 2/9,	0	8	3			
						39	15	2
	"	Received from Theodore Horne, London,				9	3	0
	"	Sold to James Jackson, Newhaven,						
		16 yards of crimson plush, at 4/11,	3	18	8			
		22 yards of green plush, at 5/3,	5	15	6			
						9	14	2
	18	Sold to Samuel Johnson, Maitland St., goods per invoice,				53	7	5
	"	Received from him cash,				100	0	0
	"	Received dividend on Roderick Dhu's sequestrated estate, 10/ per £ on £55 1/,				27	10	
	19	Received for goods sold on commission for J. Mitchell, Glasgow,				210	10	0
		Commission charged, 5 p. c.,				10	10	6
	"	Sold goods for cash,				13	3	4
	"	Paid to J. Mitchell, Glasgow,				199	19	6
	20	Paid to National Bank,				20	0	0
	"	Paid trade expenses—postage,				0	7	6
		" " police rates,				1	15	0
		" " 3 months' rent,				15	0	0
	21	Bought from Thomas Graham, George St.,						
		3 glass window screens, at £2 10/,	7	10	0			
		3 glass window screens, at £2 17/6,	8	12	6			
						16	2	6
	23	Sold to Peter Stevenson, Argyle Street,						
		6 lobby lamps, at £3 15/,	22	10	0			
		5 wall brackets, " 1 1/,	5	5				
		10 4 in. wall flower pots at 1/4,	0	13	4			
						28	8	4
	"	Received from John Brown, Greenock,				35	0	0
		Received from Peter Stevenson, Argyle Street,						
		Bill at 1 month,				28	0	0
		Allowed him discount,				0	8	4
	"	Sold goods for cash,				22	4	3
	"	Paid to National Bank,				20	0	0

1898.			£	s.	d.	£	s.	d.
Feb.	24	Paid trade expenses: advertising,				0	10	0
		" " stationery,				1	2	6
		Sold to John Reid, Edinburgh, 4 galls. varnish, at 12/6,	2	10	0			
		Cwts. qrs. lbs. 1 sheet lead, 11 3 7 at 15/,	8	17	2			
		1 c. white lead 2 1 21 " 9/6,	1	3	2			
						12	10	4
	"	Drawn from National Bank, .				90	0	0
	26	Drawn by William King, . .				10	0	0
	"	Paid T. Graham, George St., .				16	2	6
		Received from him discount, .				0	2	6
	"	Paid Robert Wilson, Birmingham, ...				37	5	0
	"	Bought from William Gray, Inverness, goods as per Invoice, ...				47	2	0

1898.			£	s.	d.	£	s.	d.
Feb.	27	Sold to John Brown, Greenock, Lbs.						
		2 boxes raisins, 87, at $6\frac{1}{2}d$,	2	7	1½			
		12 cheeses, 612, " 11d,	28	1	0			
						30	8	1½
	"	Received from James Jackson, Newhaven, ...				18	0	0
	"	Sold goods for cash, . . .				12	17	6
	28	Bought from J. Innes, Dumfries, Goods as per invoice (26 tons manure), ...				27	13	0
	"	Received for goods sold on commission for him, . .				32	15	0
		Commission thereon at 5 p.c.				1	12	9
	"	Paid bill, W. Gray, Inverness,				100	0	0
	"	Sold goods for cash, . . .				49	5	0
	"	Paid clerk 1 month's salary, .				6	13	4

CASH-BOOK.

Dr. CASH.

Date.			No	Discount £	s.	d.	Cash £	s.	d.
1898. Jan.	1	Wm. King commenced business with, ...	8				1500	0	0
"	6	Goods—Cash Sales, ...	9				72	9	0
"	14	National Bank, ...	6				25	0	0
"	21	John Coutts, Glasgow, to account,	2				10	0	0
"	22	William Miller, Dalkeith, . . .	2	0	12	9½	45	0	0
"	23	Goods—Cash Sales, ...	9				11	13	0
"	25	Charles Smith, Leith, ...	1	0	15	10	30	10	0
"	27	Goods—Cash Sales, ...	9				62	7	6
"	30	National Bank, ...	6				100	0	0
"	31	Received Bill Receivable No. 1, Roderick Dhu's Bill discounted,	3	18	0	0	282	0	0
"	"	National Bank, ...	6				110	0	0
				19	8	7½	2248	19	6

CONTRA. Cr.

Date.			No	Discount £	s.	d.	Cash £	s.	d.
1898. Jan.	1	Paid into National Bank, . . .	6				1000	0	0
"	"	Paid for Stock, ...					350	0	0
"	"	Goods—Cash Purchases, . . .	9				25	10	0
"	5	" " . . .	9				17	0	0
"	6	Trade Expenses, Postage and Receipt Stamps, ...	8				1	0	0
"	"	National Bank, ...	6				40	0	0
"	21	George Simpson, Dumbarton, .	4	0	10	0	15	10	0
"	"	National Bank, ...	6				7	10	0
"	25	"	6				30	0	0
"	"	Trade Expenses, Sundries, . .	8				2	14	10
"	"	William King, ...	8				10	0	0
"	"	William Gray, Inverness, . . .	5				71	5	0
"	30	Trade Expenses, Clerk's Salary, one month, ...	8				6	13	4
"	"	National Bank, ...	6				50	0	0
"	"	Robert Wilson, Birmingham, . .	1	4	6	6	130	0	0
"	"	National Bank, ...	6				282	0	0
"	"	Peter Paterson, Glasgow, . .	5	0	4	1	110	0	0
"	"	Balance to Dr. of next month, .					99	16	4
				5	0	7	2248	19	6

Dr. CASH.

Date.			No	Discount £	s.	d.	Cash £	s.	d.
1898. Feb.	1	To Balance from last month, .					99	16	4
"	"	" Cash for Goods on Commission for Scott & Co., ...	7				250	7	6
"	4	" Samuel Johnson, Maitland St., to account, ...	2				200	0	0
"	9	" Goods—Cash Sales, . . .	9				3	9	10
"	12	" John Reid, Edinburgh, . .	1	0	2	9	25	0	0
"	13	" John Coutts, Glasgow, . .	2				8	0	0
"	"	" John Kerr, do., . .	5				58	0	0
"	15	" National Bank, ...	6				54	0	0
"	16	" Theodore Horne, London, .	4				9	3	0
"	18	" Samuel Johnson, Maitland St.,	2				100	0	0
"	"	" Roderick Dhu, dividend on his Sequestrated Estate, . .	3				27	10	0
"	19	" Cash for Goods on Commission for J. Mitchell, Glasgow, .	9				210	10	0
"	"	" Goods—Cash Sales, . . .	9				13	3	4
"	21	" John Brown, Greenock, . .	3				35	0	0
"	23	" Peter Stevenson, Argyle Street,					0	0	0
"	"	" Goods—Cash Sales, . . .	9				22	4	3
"	24	" National Bank, ...	6				90	0	0
"	27	" James Jackson, Newhaven, .	2				18	0	0
"	"	" Goods—Cash Sales, . . .	9				12	17	6
"	28	" Cash for Goods on Commission from James Innes, Dumfries,	4				32	15	0
"	"	" Goods—Cash Sales, . . .	9				49	5	0
				0	2	9	1319	1	9

CONTRA. Cr.

Date.			No	Discount £	s.	d.	Cash £	s.	d.
1898. Feb.	1	Paid Scott & Co., for Goods sold on Commission, . . .	7				225	6	9
"	4	" Goods—Cash Purchases, .	9				13	6	6
"	5	" National Bank, ...	6				150	0	0
"	11	" Trade Expenses, Sundries,	8				1	14	9
"	"	" James Grierson, Princes St.,	7	0	15	2½	95	0	0
"	12	" National Bank, ...	6				25	0	0
"	"	" Trade Expenses—Freight, .	8				0	12	10
"	15	" Goods—Cash Purchases, .	9				54	3	2
"	"	" J. Mitchell, Glasgow, for Goods on Commission, .	9				199	19	6
"	20	" National Bank, ...	6				20	0	0
"	"	" Trade Expenses—Sundries,	8				17	2	6
"	23	" National Bank, ...	6				20	0	0
"	14	" Trade Expenses—Sundries,	8				1	12	6
"	26	" William King, ...	8				10	0	0
"	"	" Thomas Graham, George St.,	3	0	2	6	16	0	0
"	"	" Robert Wilson, Birmingham,	1				37	5	0
"	28	" Bill Payable No. 2, . . .					100	0	0
"	"	" Trade Expenses — Clerk, Month's Salary, . . .	8				6	13	4
"	"	By Balance to Dr. of next month,					325	3	11
				0	17	8½	1319	1	9

GEOMETRY.—CHAPTER IX.

THE PASSAGE FROM TRIANGLES TO PARALLELOGRAMS.

THE demonstration of Proposition XXX. (p. 712) might be varied by placing the lines A B and C D on either side of E F; and it is often advantageous so to vary the means of demonstration, to make sure that the thought expressed in the proposition has been really caught. Euclid takes great pains to see that a real understanding of what has been set before the student is attained, and on this account he places problems to be worked out, at certain advisable stages, after he has demonstrated the theorems on which their working depends. This he does here. But before encountering the problem (to be) put before us, let us clearly see what we know. Of two straight lines in the same plane which do not meet so as to form an angle, we know that they must be either (1) convergent, (2) divergent, in either of which cases they will, at one or other extremity, meet if produced far enough, or (3) parallel, *i.e.* neither convergent nor divergent, and therefore incapable of meeting. Regarding such straight lines as are parallel, we have learned that when any two of them are intersected by a third straight line (1) the alternate angles on each side of the intersecting straight line are (I. 27) equal to one another, (2) that the two interior angles on each side of the intersecting straight line are (I. 28) equal to two right angles, (3) that the exterior angles are (I. 28) equal to their corresponding interior angles on the same side of the intersecting straight line, and (4) that if the intersecting straight line is perpendicular to one of the parallel lines it is also perpendicular to the other, *i.e.* the perpendicular distance between two parallel straight lines is always the same (I. 29, 30). From some one or other of these positive properties of parallel straight lines, all their other properties may be demonstrated. By simple inspection, the student will be able to see that the perpendiculars to two parallel straight lines make the same angles with one another as the lines themselves, but he ought to set himself to prove the proposition, taking a hint for his figure from the supplementary one supplied to Proposition XXIX. (p. 712).

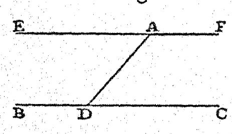
We are now prepared to face the problem which is placed before us as—

PROPOSITION XXXI.

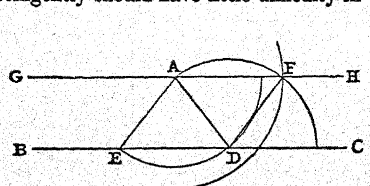
To draw a straight line through a given point, parallel to a given straight line [*of any required length.*]

We have here given us first (1) a point, and (2) a straight line B C, and we are required to draw *through* A a straight line parallel to B C.

(1) In B C take any point D, (2) join A D, (3) at the point A make the angle D A E (I. 23) equal to A D C, and (4) produce E A to F; then E F shall be parallel to B C. For the straight line A D, as it meets the two straight lines E F, B C, makes the alternate angles E A D, A D C equal (by construction), and therefore (I. 27) E F is parallel to B C; wherefore, through the given point A a straight line E A F has been drawn parallel to the straight line B C.



A figure which presents the demonstration of this problem more distinctly to the eye and mind than that usually given may be here advantageously introduced, and if we describe its construction, the student who has followed this course of lessons intelligently should have little difficulty in being able

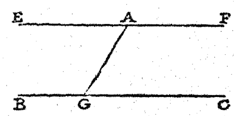


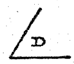
to proceed with the demonstration readily. Having the point A and the straight line B C given, we take any point D in the line B C and join A D; then with centre A and radius A D describe a circle cutting B C in E, and with centre D and radius D A describe a second circle equal to the former. Taking radius D E with centre A, describe a circle intersecting the latter one in F, through the points A and F draw the straight line G H, then this line G H will be parallel to B C (I. 28) and it is drawn through A, which was to be done.

We now pass on to a new problem which we may be able to work out, and which will help us also to understand Proposition XXXI. a little better. That is,

To draw *to* a given straight line, *from* a given point without it, another straight line which shall make with it an angle equal to a given rectilineal angle.

Let (1) B C be a given straight line, (2) A a given point without it, and (3) D a given rectilineal angle; it is required to draw *from* A a straight line which shall make with B C an angle equal to the rectilineal angle D. To do this, we proceed thus: (1) through A (I. 31) draw the straight line E A F parallel to B C, and (2) at the point A in E A F make (I. 23) the angle E A G equal to D; then A G is the line which was to be drawn. For as by construction E F is parallel to B C, the angle E A G is equal to the angle A G C; but, by construction also, the angle E A G equals the angle D; therefore (I. 29) A G C must equal D.





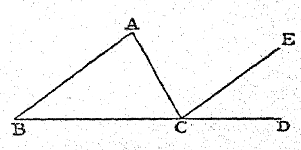
Euclid's next proposition is one of the most interesting in this book, and its results are very far-reaching. On this account it will require from the student a very large share of attention, and the most careful and critical search into the certainty of its conclusions. It comes before us in the form of a *theorem*, viz.:—

PROPOSITION XXXII.

If a side of any triangle be produced (1) *the exterior angle is equal to the two interior and opposite angles, and* (2) *the three interior angles of every triangle are together equal to two right angles.*

Let A B C be a triangle, and let one of its sides (say B C) be produced to D; then (1) the exterior angle A C D is equal to the two interior and opposite (*i.e.* the further off) angles C A B, A B C, and (2) the three interior angles—A B C, B C A, and C A B—are together equal to two right angles. Through the point C draw (I. 31) C E parallel to the straight line A B. Then, because A B is parallel to E C, and A C falls upon them, the alternate angles B A C, A C E are equal (I. 29).

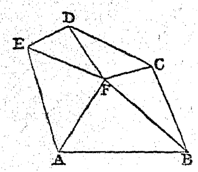
Again, because A B is parallel to E C, and B D falls upon them, the exterior angle E C D is (I. 29) equal to the interior and opposite angle A B C. Now the angle A C E, as has just been shown, is equal to the angle B A C; therefore the whole exterior angle A C D [consisting of the two angles A C E and E C D] is equal to the two interior and opposite angles C A B, A B C. To these equals add the (third) interior (and nearer) angle A C B, and the (two) angles A C B, A C D are equal to the (three) angles C B A, B A C, and A C B; but the angles A C D, A C B are equal (I. 13) to two right angles; therefore the three (interior) angles C B A, B A C, and A C B are equal to two right angles.



It may be suggested that the demonstration of this theorem might be effectively and simply worked out by (1) making (I. 23) the angle A C E equal to B A C, and (2) by inferring (I. 27) that A B is parallel to C E. In this case we need make no use of Proposition XXXI. at all. Thus we can make the alternate angles equal, and so get the parallels we require, and having got our parallels we can assuredly prove that the alternate angles are equal.

The corollaries deduced from this proposition are numerous and important. Of these the *first* is, COR. I., *all the interior angles of any rectilineal figure, together with four right angles, are equal to twice as many angles as the figure has sides.*

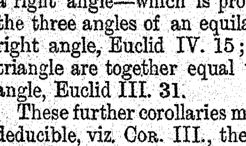
For any right-lined figure may be divided into as many angles as it has sides by drawing straight lines from a point F within it to each of its angles. Then, as we have just seen (I. 32), all the angles of these triangles are equal to twice as many right angles as there are triangles, that is, as there are sides in the figure, and these same angles are equal to the angles of the figure, together with the angles at the point F—the common vertex of the triangles, that is (I. 13, cor. 2), together



with four right angles. Therefore all the angles of the figure, together with four right angles, are equal to twice as many right angles as the figure has sides. The same result will arise if we divide any rectilineal figure into triangles by lines drawn from any angle to all the interior and opposite angles, for then each of the extreme triangles has two sides of the figure for two of its sides, and each of the other triangles has one side of the figure only for one of its sides, so that the number of the triangles is less by two than the number of the sides of the polygon. But the interior angles of the figure are equal to all the interior angles of all the triangles, *i.e.* to twice as many right angles as there are triangles, or twice as many right angles as the figure has sides, excepting those of two triangles, which are equal to four right angles. As a consequence of this corollary, when the number of the sides of any *non-re-entrant* (*i.e.* not having the angles pointing inward) equiangular figure is known, the magnitude of each angle, as compared with a right angle, can be ascertained, *e.g.* in a regular (*i.e.* equilateral and equiangular) pentagon, the amount of all the angles is twice as many right angles as there are sides, wanting four [viz. $5 \times 2 = 10 - 4 = 6$]. Each angle will therefore be one-fifth of six right angles, or one and a fifth (*i.e.* $1\frac{1}{5}$), of a hexagon $1\frac{1}{3}$, heptagon 1^3, octagon $1\frac{1}{2}$, &c.

Besides this, we come to know from this corollary that the sum of the angles of a four-sided figure is twice as great as the sum of those of a triangle, of a pentagon three times, a hexagon four times, &c.; and with a little thought—as three angles is the least number we can think of as meeting at a point—we learn that a plane space can be completely covered only by the following three regular figures, viz.; equilateral triangle, square, and hexagon; that is, by these figures alone can space about a point be entirely filled up without interstice or loss.

The *second* corollary is not less instructive and surprising. It is this, Cor. II., *all the exterior angles of any rectilineal figure are together equal to four right angles*—no matter how numerous its sides are, 3 or 3000. Because each interior angle and its exterior angle are equal to two right angles



(I. 13), therefore all the interior, together with all the exterior angles of the figure, are equal to twice as many right angles as there are sides in the figure, that is, they are equal (by the foregoing corollary) to all the interior angles of the figure, together with four right angles, and hence (Axiom 3) all the exterior angles are equal to four right angles. Thinking this result out a little, we can deduce from it that (1) each of the equal angles of a right-angled isosceles triangle is half a right angle—which is proved in Euclid II. 9; (2) each of the three angles of an equilateral triangle is two-thirds of a right angle, Euclid IV. 15; and (3) when two angles of any triangle are together equal to the third, the third is a right angle, Euclid III. 31.

These further corollaries may be readily seen to be accurately deducible, viz. Cor. III., the difference between the exterior angle of a triangle and either of the two interior and opposite angles is equal to the other interior and opposite angle; Cor. IV., if two angles of one triangle are equal to two angles of another triangle—either singly, each to each, or taken together—then the third or remaining angles in each triangle are equal; Cor. V., if one angle in any triangle be either a right or an obtuse angle, then each of the other two angles must be acute; Cor. VI., if one angle in any triangle is a right angle, then the other two angles taken together must be equal to a right angle; two such angles are called *complements* of each other to a right angle—in other words, in a right-angled triangle the acute angles are *complements* of each other. Cor. VII., any angle of a triangle is the *supplement* of the sum of the other two.

On the whole, this thirty-second proposition makes us certain of the remarkable fact that the sum of the angles contained by any three lines (*i.e.* of any triangle) is constant, and equal to the sum of the angles made at any point in and on one side of a straight line by another straight line, *i.e.* to two right angles; and it affords the basis of all those triangular measurements which afford so many valuable and practical results.

It is to be hoped that no student will accept these corollaries and remarks as accurate, without expending upon them some verifying investigation. Geometry impresses upon us to take nothing for granted which can be subjected to criticism by the reason.

BOTANY.—CHAPTER IX.

FRUITS—THEIR CHARACTERISTICS AND PROPERTIES.

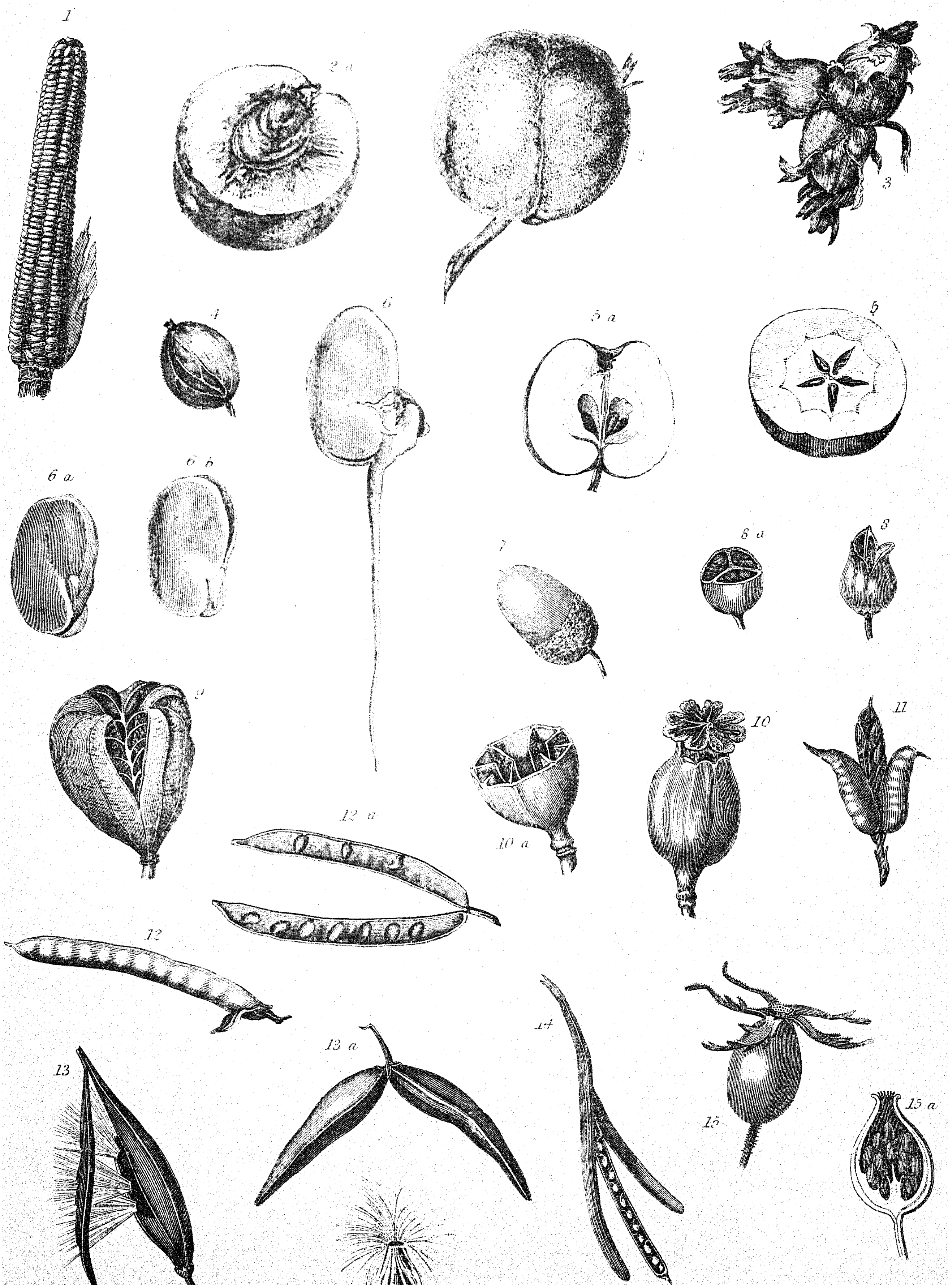
People often murmur at the repellant technicalities of botanists, and the dull details they accumulate regarding the favourites of nature and those delights of humanity—flowers and fruits. One must remember, however, that flowers and fruits are very numerous, and that their varieties are almost countless, even when we do not include those founded on petty and trivial or merely accidental differences. It is essential to intelligent speech regarding anything that words expressive of the qualities, properties, characteristics, &c., of such things should not only exist, but also be used readily and with well-defined significations. Curiously enough, everyone is indulgent to the technicalities of that particular department in which he is engaged and most deeply interested, while intolerant of the barren and useless array of specific terms employed by others concerning their specific pursuits. He feels the need of the one: he does not appreciate the necessity of the other. As an instance, we may mention the pansy or heart's-ease, to which in folk-lore many names are given, such as, love-in-idleness, herb-trinity, three-faces-under-a-hood, kit-run-about; but on special varieties of which gardeners year after year bestow so many names (in honour of kings, queens, nobles, cultivators, the incidents of political or social life, &c.), that no botanist could burden his memory with them, and yet to the gardener they have each a distinct meaning, and all a given use. Or to take an illustration from the subject more immediately under consideration now, botanists distinguish and designate the specific sorts of fruits by several names, of which the *pome* is one and the apple is a sample; but nearly nine hundred names are employed by growers and fruit merchants to particularize the several varieties of the apple-fruit—each recognizable by a good judge with discriminating skill. Even the Golden Pippin rejoices in the possession of at least sixteen such names—each implying certain marks of distinction. It seems to be a necessity of thought to have distinct names for ideas which can be well defined in the mind. It is not therefore owing to a mere love for technicalities that, on a botanist's page, we find many words which are not used (nor, except in rare instances, requiring to be used) in ordinary language—such as the various designations of fruits.

As a mere matter of fact, botanical language is, in no part of its vocabulary, so defective as it is in the naming of the specific classes of different fruits. Indeed, no universally adopted classification of fruits, as the products of fruiting plants, has as yet been determined upon. In this matter the language of theoretical botany and of practical life have not been brought into harmony one with another. In a sort of rough-and-ready way, influenced, in the main, by their general outward resemblances, and the practical uses to which they can be applied, men have formed a kind of classification of fruits which suits very well probably for practical purposes, but is not at all scientific. In scientific classifications, such as govern the language of botany, the word fruit has a very specific signification. The *carcerule*, or seed-like grain or nut of

BOTANY.

PLATE X

SEED-VESSELS & FRUITS



the sage (*Salvia*), the *cypsele* or obtuse-topped achene of the daisy family (*Bellis*), the *caryopsis* or dry one-seeded grain of corn, the capsule of a lilac, and the nut of the chestnut, are all "fruits" in botanical usage, though they have no very readily seen resemblance to a peach or a pine-apple, a grape or a strawberry. On the other hand, the botanical order of a plant does not necessarily imply the possession of sameness of fruit. Among the *Rosaceæ* (or rose-plants) we have herbs, shrubs, and trees, some of which produce as fruit one-seeded nuts (*nuces*); bunches of succulent berries (*acini*); apple-like many-celled fleshy masses (*pomes*); skin-covered, pulpy and juicy, stone-containing or kernelled matter (*drupes*); double-valved, bellows-like, one-seeded vessels (*folliculi*), &c. In this way we have, comprised in one order, the pretty velvety, white, purple, or yellow-leaved potentillas, with blossoms shaped like the wild rose, which develop a fruit containing numerous small nut-like grains on a dry receptacle; the cymose-flowered, follicle-fruited meadow-sweet; the succulent, receptacled strawberry; the fleshy-fruited apple and pear; and the dry-druped woolly-skinned almond.

It will, perhaps, in a popular outline of botany like the present, be best to fix in the mind some distinct ideas of the chief sorts of fruits generally known and recognized, and through them to introduce the reader to a knowledge of fruit in a scientific sense. Meanwhile, a few technical distinctions and terms had better be, in some measure, explained and placed properly before the student.

Fructification, or fruiting, is the chief function of plants. The mature ovary constitutes the fruit, and the mature ovules the seeds of plants. In the popular acceptation of the term fruit other parts of the flower are also sometimes included; as the pulpy disc or receptacle in the strawberry, the united calyx and ovary in the apple and gooseberry, and the bracts and calyx united into a cupula or cup containing the acorn. When we examine fruits as botanical subjects, not as edible products, we find great differences in their form and nature. Hence they may be regarded as falling into different classifications. In one way they may be classified as *simple* or *multiple*. Sometimes important changes take place in the process of transformation of ovary into fruit. The ovary may be unilocular, and afterwards develop into a multilocular fruit, or the ovary may be multilocular and the fruit unilocular. In the ash a two-celled ovary is replaced by a one-celled fruit. In Cassia fistula a one-celled ovary becomes a multilocular fruit. Simple fruits are such as are produced by a single flower-carpel. In this mode of classification the pod of the pea, the bean, the vetch, &c., would be regarded as a simple fruit, because it is the ripened ovary of a single flower. Multiple fruits are those which are the product of several flowers. The mulberry, the fir-cone, the pine-apple, the fig, &c., are multiple fruits because they consist of a number of ripened ovaries, produced by many flowers clustered together on a single peduncle, all combined in one mass. Multiple fruits again may be divided into two classes—*composite* and *compound*. The fruit of the strawberry, consisting as it does of an aggregation of ripened pistils compactly associated in a flesh-like foundation, is *composite*, while the fruit of the orange and the lemon, resulting from the union of two or more ovaries, so completely fused together as to form an organic whole, is a *compound* fruit. From another point of view they may be divided into *dry* and *succulent*. In this sense dry fruits hold no resemblance to the dried fruits of commerce. The seeds of the thistle and the dandelion are formed on receptacles similar to those of the strawberry and the raspberry, but the former are dry and the latter succulent. The *cones* of pines and the *soroses* of pine-apples are also examples of the difference between dry and succulent fruits. (1) The mature ovary, whatever its substance, and however complex its structure may be, is called the *pericarp*; and the pericarp, when theoretically perfect, consists of (i.) the pellicle, outer layer, skin, or rind, called *epicarp*, (ii.) a middle layer, if tegumentary, named the *mesocarp*, but if fleshy or succulent, the *sarcocarp*, and (iii.) the inner layer or *endocarp*, which likewise receives the name of the *putamen*, or the stone. In some fruits these three parts are not readily distinguished, in others they are seen plainly and at once. (2) The contents of the pericarp, that is, the impregnated ovules, consisting of the embryo and any nourishing matter that may surround it, is called the *seed*. (3) The ovary may consist of one carpel or of several, but through the over-development of some and the non-development of other parts of the flower the fruit may differ from the ovary, though, as a general rule, the fruit agrees with the ovary in the number alike of cells and seeds. Only we must remember that owing to the development of succulent (or other) matter, sometimes in one part and sometimes in another, it is not always easy to determine these. (4) Fruits formed from one flower are (i.) *apocarpous*, formed from one carpel, (ii.) *aggregate*, formed from several free carpels, and (iii.) *syncarpous*, formed from several intimately united carpels; but fruits formed by the incorporation of the ovaries of many flowers are designated *anthocarpous* or collective.

According to the manner of their opening, in order that their seeds may be liberated, fruits are classified as *dehiscent* and *indehiscent*. The former is the name given to those which open naturally, the latter to those which do not. Dehiscent fruits may separate by both sutures or only by one, or they may carry the placenta with them or leave it standing. In the latter case it is called a *columella*. The separation may proceed from the base to the apex, or from the apex to the base. Transverse divisions sometimes also occur.

Dehiscence may also take place by means of orifices or pores, as in the poppy. (Fig. 10, Plate X.)

Fruits composed of a single carpel may dehisce by one suture only or by both. This kind of dehiscence is called *sutural* (see pea, fig. 12A.)

Fruit composed of several carpels united may dehisce through the dissepiments, so that it is again resolved into its original carpels. This kind of dehiscence is called *septicidal*. See beech-nut (fig. 8).

If the carpels remain united at their edges and dehisce through the back of the loculaments, each valve being formed by the halves of contiguous cells, is called *loculicidal*. Example, yellow iris.

If the fruit opens by the dorsal suture and the septa remain attached to the centre, it is called *septifragal dehiscence*.

Indehiscent fruits may be classed in two divisions, containing one or more seeds respectively, and those containing one seed may again be subdivided into dry and fleshy.

Dry indehiscent fruits with one seed are—Achenium, with a pericarp separable from the seed (ex. sun-flower); caryopsis, with a pericarp inseparable from the seed (see maize, fig. 1); utricle, with an inflated pericarp (ex. chenopodium); glans, with a hardened pericarp, accompanied by bracts at the base (see acorn, fig. 7); samara, with a winged pericarp (ex. sycamore).

Pulpy indehiscent fruits with one seed—Drupe, with a succulent mesocarp and hard endocarp (ex. cherry).

Pulpy indehiscent fruit with more than one seed—Berry, a succulent fruit in which the seeds are immersed in a pulpy mass (see gooseberry, fig. 4); pome, in which the calyx, with the epicarp and mesocarp, forms a fleshy mass, and the endocarp is scaly and horny, forming separate cells inclosing the seeds (see apple, fig. 5).

Dehiscent fruits are all dry. Those which are apocarpous are—Follicle, a carpel having no dorsal suture, and dehiscing by the ventral suture (fig. 11); legume, a carpel having dorsal and ventral sutures, and dehiscing by both or either (fig. 12). Those which are syncarpous are—Capsule, opening by valves or pores (see poppy, fig. 10); pyxidium, capsule dehiscing by a lid (ex. henbane); siliquæ, capsule opening by two valves, detached from below upwards, leaving the seeds attached to both sides of a replum (see wallflower, fig. 14); silicle, a pouch or short pod (ex. candy-tuft).

Anthocarpous fruits—Sorosis, a succulent anthocarpous fruit (ex. pine-apple); syconus, a pulpy hollow axis inclosing the achenia of numerous flowers (see Fig, fig. 9); strobilus, a spike covered with scales or bracts with seeds at their base (ex. fir-cone, hop).

We shall now give a description of some of the more commonly recognized fruits, which will help the student to understand their botanical structure, and be an aid to him in learning their scientific nomenclature.

I. Pomes or Pip-fruit (*Pomaceæ*, from Lat. *pomum*, an apple), a form of fruit generally presenting a fleshy pulpy mass

surrounding a capsular part called the *core*, and containing the seed. They are from one to five celled, and sometimes, spuriously—as botanists designate such a variation from a usual order—they have ten cells. The following are some of the chief subclasses:—

(1) *The Apple* (*Pyrus Malus*, figs. 5 and 5A), is a fruit whose crisp solidity of edible matter occurs in varied shapes—globular, oval, oblate, conical, cylindrical, angular (*i.e.* flattened into facets) or ribbed (having ridges on its surface with hollows between). Its fleshy succulent pulp is inclosed in a thin outer skin, varying much in colour, but most frequently "with gold irradiate and vermilion shines." The ovary of the apple being situated below the flower, enlarges, at the point where the stalk meets the flower, into the pome, on the summit of which traces of its five-cleft calyx remain. In the core, protected by cartilaginous walls, the seed lies safely ensconced in cells pointed at both ends.

(2) *The Pear* (*Pyrus communis*).—This pulpous fruit has a soft melting consistency of flesh, often intermixed with gritty concretions of woody matter. Its double-seeded five-celled endocarp is cartilaginous, and its cells are pointed only at one end. It is pyramidal in form, and its base is generally convex.

(3) *The Quince* (*Cydonia*).—The pome of this fruit, sometimes globose and sometimes pear-like, varies in form and size. When young its peel is downy, and richly orange-hued when ripe. In each of its five cells, mucilaginous seeds, varying from twelve to forty in number, may occur. It is strong-flavoured and austere, and hence more valued for scent than savour.

(4) *The Medlar* (*Mespilus*, "half-ball").—The swollen expansion of the mesocarp of this pomal fruit resembles in internal structure its congeners; but outwardly, owing to the calyx spreading over the entire head of the pome, it presents not a rotund, but rather a top-like form. Its rind is of a dull russet-brown colour. In its core, the usual five cells are found containing two pips each, though the leathery enwrapments of the seeds in the other *Rosaceæ* are in this changed into hard, wrinkled, stony or bony shell, the upper ends of which are exposed. Its pome is not used till *bletted* (*i.e.* just beginning to decay).

Among the *Pomaceæ* also occur the White Beam-tree (*Pyrus Aria*), whose fruit is scarlet; the Rowan or Mountain Ash (*Pyrus or Sorbus aucuparia*), whose beautiful *red berries* are really pomes; the Service (*Pyrus or Sorbus domestica*), with obovate fruit resembling a small pear, which in the Sorb (*Pyrus Torminalis*) is spotted; the Hawthorn (*Cratægus*), whose small oval or round fruit has a yellow pulp and a central stony endocarp, very large in proportion to the pulp surrounding it.

II. Baccates or Berry-fruits.—These consist of a spherical pericarp of soft succulent pulp, in which the small separate seeds (more or less numerous) lie loosely imbedded. The berries may appear (1) in clusters or (2) singly, and may be thick or thin in skin. Hips (fig. 15), haws, and plums, though often spoken of as berries, are not so, because their seeds do not lie loosely in the pericarpal pulp. The brambleberry, including all its subspecies—blackberry, cloudberry, dewberry, and raspberry—though bearing this name, are not botanically regarded as berries; they are really succulent drupes formed upon an elevated dry receptacle. The botanical fruit of the strawberry are the numerous small nut-like grains which lie upon the succulent receptacle which is popularly known as that favourite fruit, the Strawberry (*Fragaria*). Of berries, the chief types used as fruits are these:—

(1) *The Grape* (*Vitis*).—This shapely, richly-tinted fruit, in one case leek-green as a chrysoprase, in another hanging forth suspended clusters glowing with the deep-brown translucency of amber, and again festooning with glorious purple the elm or poplar to which their twining tendrils have attached them, is the highest type of a berry—a mass of juicy pulp, inclosed in a fine bloom-shaded skin, having floating within its sweet syrup, in its normal state, one seed for each of the five stamens of its five-petalled flower, though not unfrequently so many stones are not found in them.

(2) *The Gooseberry* (*Ribes*, fig. 4).—In this large juice-filled berry the seeds do not float freely, but are attached in two groups by soft, firm ligaments to the sides of the transformed ovary, while the calyx, though withered and brown, keeps its place at the top of the berry. Though the currant has more numerous blossoms, and its fruit grows in racemes or little stalklets hanging from the main stalk, and each carries only a single berry at its end, it is classed as a member of this same genus, because it has the same number of parts similarly disposed.

(3) *The Barberry* (*Berberis*).—The strikingly lively clusters of little, elongated, oval, scarlet berries which hang in loosely drooping groups from the branches of the thorny bush which they adorn, are found to have, in their fleshy, acid mesocarp, two or three seeds in each berry.

(4) *The Bilberry, the Cranberry, and the Whortleberry* (*Vacciniece*).—The small dark-purple or black berries of the *Vaccinium myrtillus* of the botanists, and the bilberry, blaeberry, huckleberry, or whortleberry of the common people, are round, and covered with a delicate grape-like bloom. They are four or five celled, and these cells each contain one seed or more. The fruit of the cranberry (*Oxycoccus palustris*) is scarlet. These berries grow in small clusters at the ends of the branches, one on each extremity of their slender elegantly-bending flower-stalks. The crimson fruit of the cowberry, which also grows in racemes at the end of the branches, is sometimes used instead of the cranberry; but it is the *Vaccinium* (*Vitis*) *Idæ* of the botanist. A white-berried variety of the latter is also sometimes to be met with.

We come next to a series of fruits which are by botanists regarded as berries, or modifications of the berry, though it would be difficult perhaps to harmonize this real fact with the idea popularly (yet unscientifically) held regarding them. The mesosarcal portion of their pericarp is hard and firm, and their epicarp or rind is leathery (*i.e.* they are thick-skinned). Of these the following may be noted:—

(i.) *The Orange, Lemon, Citron, and Shaddock* (*Citrus*).—These golden-robed globose fruits are really large berries, inclosing within their tough, oily, aromatic, and leather-like peel a peculiar pulp, consisting of a number of vesicles filled with the finely flavoured juice for which they are famous. The central ovary seems, though now apparently undivided, to have been originally divided into from five to fifteen parts, each containing from six to twenty ovules. These divisions are still represented by the thin membrane which separates the *liths* (*i.e.* the partitioned sections) one from another. The ovules do not always become perfect pips, so that, though there are usually seeds in each division encased in a cartilaginous membrane, some species of oranges are notably seedless. This berry, which in most minds has taken the place of the type of an "oblate spheroid," exactly imaging "the figure of the earth," is in reality—as is conclusively shown in "L'Histoire naturelle des Oranges," by Risso of Nice, and Poiteaux of Versailles—most diversified in form and various in colour. In the citron and lemon, which are of rich saffron tint, and elliptical in form, one end is protuberant, like a nipple.

The Shaddock or "Sweet-ball" is a large, pale, globular fruit, whose pulp is less juicy and pleasant-flavoured than the other members of the order.

(ii.) *The Pomegranate* (*Punica*).—Looking at the rounded plumpness of its form, and noting that the tube of the persistent calyx, increasing in size, becomes the outer rind of the fruit, one might readily fancy this was a *pome*. Its outer case, however, is not like the apple, a mass of edible pulp, but a dry leathery coat surrrounding the berries within it, which are each distinct, of oval shape, about the size of a red currant, and having, like it, a thin enveloping skin containing a globe of transparent succulent matter. These berries are regularly set in double tiers, of from five to nine cells above and three below, each tier being separated by integumentary membranes from the other.

As a sort of supplement to what has been said regarding berry fruits, it may be just as well here to notice (1) several collective, and (2) several aggregate fruits. To the former of these belong (1) the Bramble (*Rubus*), in which each seed is surrounded by a separate pulp and skin, though all proceed from one blossom, and are found collectively on one dry spongy mass or receptacle, from which the real berries may be picked off singly—such are the blackberry, cloudberry,

dewberry, raspberry; (2) the Strawberry (*Fragaria*), which is remarkable for having the receptacle, which is popularly regarded as the fruit, formed into a juicy and edible cushion, studded with seeds, swelling its luscious crimson outgrowth between and around the irregular oval seed-grains, which are each wrapped in two skins and divided into two lobes, between which the embryo is lodged. As many as 300 ovaries, Duchesne says, have been counted on one of these nectared cushions.

(3) *The Melon* (*Cucumis*).—This large well-known fruit—with its many relations, the Gourd, the Cucumber, the Squash, the Vegetable Marrow, the Colocynth, and not only the Pumpkin, but the Bryony—has flat, ovate seeds (which are the botanical fruit) embedded in a pulp, which is in some of the 300 species included among cucurbits, dry and in others juicy. The Water Melon is of a different species, and called *melos citrullus*; it is smooth, green in surface, and roundish or oval in form, and its seeds are very dark brown or entirely black.

Of *aggregate* fruits (*i.e.* those in which the popularly named fruit is formed by the cohesion of many *calyces*), the most deserving of mention are perhaps the following:—

(1) *The Mulberry* (*Morus*).—In this plant numerous flowers combine and cohere to form one fruit, which is composed of the receptacle, the calyces, and the ventricles, consolidated into one succulent mass of fleshy pulp, each ovary maturing in its two-celled space a single seed, so that these seeds really do seem to be imbedded in pulp, and yet the dividing markings of these conjoined parts show that, though indivisible as a fruit, they are the product of the formative parts.

(2) *The Fig* (*Ficus*, fig. 9).—The fig is fruit and flower in one. Those green, fleshy, protuberant pouches (as they may be called) which spring out from the axils of the leaves, contain, inserted in the inner surface of their integumentary receptacle, quite a cluster of small unisexual florets, the male blossoms occupying the upper portion of the bag, while a number of female ones occupy the lower space. The ovary of each of these latter florets develops a seed surrounded by a glutinous pulpy substance; and so, when ripened, we have a succulent pear-shaped pouch of seed very much resembling a brownish-purple berry, though formed so differently.

(3) *The Pine-apple* (*Bromelia*).—This fruit shows on a large scale what the mulberry shows on a small one, a number of parts usually distinct, growing and aggregated into one succulent mass. The fruits into which the small close-sitting flowers of this plant develop upon its three-cornered calyx, are scattered over, and somewhat imbedded in, the thick fleshy receptacle on which they are supported, which distends with juice and forms one pulpy mass, of which the points seen on its surface—called pips—show the original calyces; the crown is really the end of the stem, on which what is called the pine-apple—but which is botanically a conglomeration of capsules or berries bearing seed—has grown, finished off with a crowning cluster of leaves.

III. Drupes or Stone-fruit.—A drupe is an ovary ripened into a fruit, possessing an outer succulent mesocarp, surrounding the endocarp as an inner stony portion or kernel (*i.e.* the ovule grown into the seed). The almond, though its outer portion is not succulent, is classed by botanists among drupes. Of drupe-fruits the following may be noted—viz.

(1) *The Plum* (*Prunus*).—The fleshy drupes of the prune tribe form a graduated interlink between the soft berries of summer and the firm pomes of autumn, and include a large variety of fruits, from the sloe to the greengage. In the former we have little azure-bloomed balls inclosed in a violet skin, which are formed by the ovaries alone. Next come the more globose and variously coloured bullace, the *Prunus domesticus* (including the cerisette, the damson, the *magnum bonum*, the golden drop, &c.), and the greengage, in which the plum seems to be perfected. Plums are divided into (1) those in which the fleshy part adheres with some firmness to the stone, and (2) those in which the succulent part separates readily from the stone. In some plums there is a suture or furrow indenting one side of the fruit; in others this joining is not visible. The apricot is really a plum. Its fine peach-like fruit, roundish, downy, sweet-juiced, and generally yellow, but ruddy on "the side that's next the sun," has within it a smooth kernel sometimes bitter and in other cases sweet, which, unlike the other members of the plum species, is pointed at but one end.

(2) *The Cherry* (*Cerasus*).—The shining, ruddy, smooth-skinned, tasty ball of tender, juicy, but firm-fleshed pulp of the cherry, consists of a single ovary, round the hard-fluted kernel or bony seed-case of which it has enlarged and forms a true drupe, whose delicate juicy globes show beautifully the accuracy of Goethe's theory of the metamorphoses of plants.

(3) *The Peach* (*Persica*, fig. 2) is a large drupe, clothed in a thick velvet-like skin, varying in colour from dark-red violet to green and yellow, and inclosing an exquisite sweet-juiced pulpy plumpness, in which there lies imbedded an oval kernel. These also are divided into those whose flesh (1) adheres to, or (2) parts readily from their roughened and irregularly furrowed stones. The Nectarine, though it has a smooth and wax-like skin, is a variety of the peach.

(4) *The Date* (*Phœnix*).—This fruit is a single-seeded drupe which grows in clusters on the palm. Like the seed of all endogens, of which the palm is one, the date is monocotyledonous. It forms one oblong cylindrical undivided kernel, looking very like a greatly enlarged grain of rye, marked along one side with an indenting furrow. In this solid albuminous mass, one little speck of embryonic plasma is hidden, usually near the end most remote from the *hilum* (*i.e.* the scar which marks where the kernel was attached to the fruit).

Botanists also rank among drupes several fruits which are not popularly regarded as of the same kindred with those of which we have just been speaking; *e.g.*

(i.) *The Almond* (*Amygdalus*).—This coarsely furrowed and wrinkled shell, inclosed in a dry, fibrous husk, which shrivels as the fruit ripens, and opens when the seed is mature, is classed botanically along with the peach, which it resembles in growth, foliage, and blossom, though a husk instead of a succulent mass forms its sarcocarp and incloses its kernel. This kernel is the article brought to the market and placed on our tables. Almonds are of two varieties—the bitter and the sweet.

(ii.) *Pistachio Nuts* (*Pistacia*).—This is also a dry drupe, green-hued though red-tinged, ovate, and about the size of an olive. When ripe the drupe (or nut, as it is commonly called) splits into two halves (or valves) to liberate the kernel, which is inclosed in a violet-coloured pellicle, is bright green in colour, delicately flavoured, and highly oleaginous.

(iii.) *Cocoa* (*Cocos nucifera*).—The cocoa-nut is a one-celled drupe, the growth of a three-celled ovary, of which two have become abortive and leave only two round scars, sometimes called "eyeholes," to bear witness to their being. That single scar which can be punctured with a pin is the intended outlet of the embryo, for the nourishment of which the *milk* is intended. The pericarp is fibrous, the endocarp thin and brittle.

IV. Nuts or Shell-fruit.—A nut, which in ordinary language includes all sorts of fruits inclosed in a hard, woody, or leathery case, which does not open itself when ripe, is in botanical language restricted in its use to designate a large, hard, dry, one-celled fruit containing, when mature, only a single seed in a hardened pericarp readily separable from the kernel. A small, hard, one-seeded fruit, having the integuments of the seed closely applied to, though distinct from, the pericarp (such as the fruit of the dead-nettle) is called an achenium, to distinguish it from a nut (*nux*). Of these the most noteworthy are:—

(1) *The Hazel and Filbert* (*Corylus*, fig. 3).—The former is the fruit of the wild, the latter that of the cultivated nut-bush, whose distinguishing character is the capsule (*i.e.* the cup-like covering), formed by the cohering of a number of bracts around the fruit, as a *husk*, or at the base of the fruit, as the acorn of the oak; for, as Cowley has said, "the fruit which we a *nut*, the gods an *acorn* call." This is the enlarged involucre of the female flower. It forms a bell-shaped, leafy, and laciniated (*i.e.* indented or jagged) cup, which opens at the top when the fruit is ripe, so that it may drop out. The nuts, formed on an amentum or catkin, grow in clusters, and are closely joined together at the bottom. The cupule of

the hazel is shorter than the nut. Both the nut and the husk of the filbert are larger than those of the hazel.

(2) *The Walnut* (*Juglans*).—This is really a *drupe* with a deciduous fleshy husk. On bursting, which it does irregularly, it allows its hard-shelled, two-valved nut to fall out. Within this shell is the vertically-partitioned, curiously-lobed, and wrinkled seed, inclosed in a membranous skin. Hickory nuts and butter nuts are American varieties of this drupaceous nut family.

(3) *The Chestnut* (*Fagus*).—The chestnut is the single-celled seed-vessel of the round, densely spiny involucre which forms the husk of trees of the genus *Castanea*, which opens by valves, and contains one, two, or three nuts inside. It may be as well to mention here that the horse-chestnut, though seemingly related both in appearance and in name, is no botanical connection. The outer prickly, three-valved, capsular husk, the inner brown, leathery wrapping, and the white solid substance of the nut are points of resemblance; but the husk of the latter is a pericarp, in which the real seeds are stored, while that of the former is an involucre (*i.e.* a collection of bracts) really constituting a seed-vessel.

What is called the cashew-nut appears on a West Indian plant, *Anacardium occidentale*, on a fruit which has the appearance of a red or yellow pome, but is in reality the flower-stalk thickened and become succulent. From the thick end of this apparent pome, which is edible, this kidney-shaped nut—so much relished in the West Indian Archipelago—projects.

Although not quite so commonly spoken of popularly as fruits, we may add to what we have already said :—

V. Legumes or Pod Fruit (of which the bean, fig. 6, the pea, fig. 12, and all sorts of *pulse* plants are examples).—In this order of *Leguminosæ* broom, laburnum, clover, liquorice, lupin, senna, &c., tamarind, logwood, indigo, &c., acacias, mimosæ, &c., are included. These plants have the ovary in general single-celled, consisting usually of a two-valved single carpel, and the seed are sometimes solitary, though frequently numerous. Legumes for the most part, though not invariably, open when ripe, and in some cases they are divided by diaphragm-like partitions. A *Silicle* is a short two-valved pod almost as broad as it is long, ovate as in garden-cress, wedge-shaped as in shepherd's-purse, and roundish, compressed, or oblong, as in *Lunaria bucinis* (honesty).

VI. Cones.—These are fruit-bearing spikes, formed of the scale-shaped ovaries, enlarged and hardened into a wood-like substance. Each of the scales has two seeds at its base. They are closely compacted together till they require to open for the emerging of the seed. The form of fruit is well-known in the fir-top or pine-cone. In the hop the scales are loose, in the juniper they are fleshy, and form what is generally, though wrongly, regarded as a berry. The yew is a suborder of the Coniferæ, though the pulpy, bright red, roundish fruit of the yew does not resemble a cone, but is rather something like a drupe, with a solitary ovule in the centre of a fleshy disc forming a succulent cup.

It would be vain, even in a volume, to attempt to describe all the forms in which the nestling seeds of plants may be found —the prickly homes in which they dwell, the chambered cups in which they hide, the luscious liquid-cases in which they float, the nectared pomes wherein they lie, the long pods in the down of which they rest, the strong capsules in which they are stored, the satiny bloom which encircles some, the strong-textured rind which incloses others; the homeless unprotectedness of some, like the seed of the nasturtium or the spore of the fern, as compared with the helmeted filbert or the well-cradled cocoa. It may, however, be possible, from what has been said, to form some idea of the main distinctions of fruits one from another, and to group any ordinary ones which may occur in the student's experience under one or other of those classes presented in the foregoing outline—an outline in which it has been attempted to lead the thoughts of the reader from the common everyday knowledge of frequently seen fruits to some acquaintance with the characteristics and classes of the fruits recognized in scientific botany—which in all cases signify the vessel, of whatever sort it may be, which contains the seed intended to result in new plants similar to those which communicate to them the inheritance of life.

THE GERMAN LANGUAGE.—CHAPTER XI.

PREPOSITIONS DEFINED, CLASSIFIED, AND EXPLAINED—COMPOUND VERBS—EASY READING LESSONS—IMITATIVE COMPOSITION EXERCISES.

The use of Prepositions in German involves a larger number of peculiarities than ordinarily occurs in regard to parts of speech which are reckoned as invariable. They are it is true, uninflected; yet the differences of their signification and usage are not only numerous, but often unexpected. It is very far from enough to know and to use the literal translations commonly given in lists of German prepositions as if they were invariable equivalents. A phrase which in English requires a specific preposition may in German demand quite a different one. If we define a preposition as a part of speech employed to express the relation in which the conception named by one noun stands to that named by another noun or asserted by a verb, we shall immediately see the reason for this difference. The main characteristic of a preposition is that it deals with our conceptions of the relation of things, acts, purposes, &c.

Now not only are the relations of things and thoughts manifold, but men's capacity for realizing and recognizing these differ very much. The most common and palpable cases of relation are almost universally perceived and appreciated, and hence in by far the greater number of languages —as in German, though not in English—some indication of these common relations are incorporated with nouns and adjectives under the designation of cases. For example, take the sentence—The brother gave the father's key to the coachman. Here there arises the relation (1) of giver, and we ask who was the giver? to which the answer is, der Bruder gab, the brother gave—the brother being in the nominative case. (2) Of the thing given: the brother gave what? To this the answer is direct and plain—der Bruder gab den Schlüssel. "Key" is in the accusative, as being the direct object given. (3) Of possession: whose key was given? To this the full categorical reply would be, der Bruder gab den Schlüssel des Vaters, where the name of the possessor is put in the genitive case. (4) Of the receiver: to whom was the key given? To that question the grammatical answer might take either of the two following forms, der Bruder gab den Schlüssel des Vaters dem Kutscher; or according to a way of speaking more usual in German, der Bruder gab des Vaters Schlüssel dem Kutscher.

But there occur to the mind, by experience and reflection, ideas of relations, for the expression of which the provision made by the grammatical cases are neither definite enough nor sufficiently numerous. Hence it has been found necessary to mark these relations in a more specific manner by the use of a class of words appropriated to this work, *i.e.* by *prepositions*. In the following phrases, for instance, the use of the genitive case would not convey the more peculiar and delicate shade of meaning which is suggested by the preposition von; as Die Befestigungswerke von Paris, The fortifications of (*i.e.* belonging to, in and around, for the defence of) Paris; Ein Vater von acht Kindern, A father of (*i.e.* having) eight children; Ein Knabe von fünfzehn Jahren, A boy of (*i.e.* who has reached) fifteen; Ein Mann von Geburt, A man of (*i.e.* well-descended by) birth. In the same way it will be seen that the specific nature of the relation expressed by the prepositions um and von, with the accusative following them, could not be indicated were the noun alone employed in the accusative; as Er bat um sein Geld, He asked for his money; Ich habe keine Antwort von ihm erhalten, I have received no answer from him.

This part of speech has received the name of preposition, not from the nature of the office it fulfils in the expression of thought, but because in the Greek and Latin, as indeed in most other languages, the words so employed are commonly (though with some exceptions) *præposita*, *i.e.* placed immediately before the nouns to which they refer, and the relations of which, one to another, they indicate or suggest.

Prepositions govern cases of nouns, and thus indicate the direction of some action to or from one person or thing to another, or indicate some relation of place, time, circumstance, &c. As prepositions express different relations they

naturally differ in the cases they govern, and are arranged into four classes accordingly, as will be seen below by the numbers placed in brackets after each. The first class (1) governs the genitive case; the second (2) the dative; the third (3) the accusative; while the fourth (4) governs sometimes the dative and sometimes the accusative. The meaning of prepositions of the fourth class varies according to the case of the noun they govern; so that as every noun in German begins with a capital letter, the preposition is often helpful in enabling the reader to distinguish the case of a noun, and the knowledge of the case aids in giving the proper signification to a preposition.

ALPHABETICAL LIST OF THE MOST USUAL GERMAN PREPOSITIONS, WITH EXAMPLES.

Prepositions	Significations.	Examples.
Ab (2),	of, from, down,	Von Morgen ab soll kein Schiff mehr passiren, From to-morrow no vessel is to pass down.
An (4),	at, to,	Er geht an den Rhein, He is going to the Rhine. Frankfurt am (an dem) Oder, Frankfort on the Oder.
Anstatt (1),	instead of,	Anstatt meines Bruders, Instead of my brothers.
Auf (4),	on, upon,	Ich trage einen Brief auf die Post, I am carrying a letter to the post. Wir wollen dieses schöne Wetter benutzen, und ein wenig aufs Feld gehen, Let us take advantage of this fine weather and go a little way into the country.
Aus (2),	out of,	Er kommt aus der Fremde, He comes from abroad.
Außer (2),	besides, without,	Außer Schuld, außer Gefahr, Out of debt, out of danger. Ihre Krankheit außer dem Bereich der Medicin liegt, Your complaint is beyond the reach of medicine.
Außerhalb (1),	without, outside,	Mein Haus liegt außerhalb der Stadt, My house lies outside the town.
Bei (2),	near, by, at,	Sie blieben bei uns, They remained with us.
Binnen (2),	within (of time),	Er wird binnen einer halben Stunde zurück kommen, He will come back within half an hour.
Bis (3),	until, till,	Wir spielten kegelspielen bis Mitternacht, We played at ninepins till midnight.
Diesseits (1),	on this side of,	Diesseits der Themse, On this side of the Thames.
Durch (3),	through,	Viele Menschen bereichern sich durch Handel, Many men enrich themselves by commerce.
Für (3),	for,	Dieser Mann hat keinen Sinn für das Wahre, This man has no sense (of) for truth.
Gegenüber (2),	opposite (it is placed after its noun).	Sein Haus liegt an dem Platze und meine Wohnung war demselben gegenüber, His house is situated in the square, and my lodgings were opposite it. Der Kirche gegenüber, Opposite the church.
Gegen (3),	against, towards,	Erst gegen Morgen ist er eingeschlafen, He fell asleep only about morning. Es waren ihrer gegen hundert, There were about a hundred of them. Gegen den Rath seiner Freunde, Against the advice of his friends.
Gemäß (2),	according to (placed after its noun).	Ihrem Auftrage gemäß, According to your commission.
Halben or halber (1),	on account of (behalf of),	Der Folgen halben, On account of the consequences.
Hinter (4),	behind,	Er stellte sich hinter meinen Stuhl, He placed himself behind my chair. Das Dorf liegt hinter dem Hügel, The village lies behind the hill.
In (4),	in, into,	In unserm Hause, At our house. In seinem Hause, At his house.
Innerhalb (1),	within,	Innerhalb der Stadt sind viele Plätze, Within the town there are many squares.
Jenseits (1),	on the other side of,	Jenseits der Donau, On the other side of the Danube.
Kraft (1),	by power of, by virtue of,	Ich befehle dir kraft meines Amtes, I command thee by virtue of mine office; kraft des Gesetzes, by the power of the law.
Laut (1),	conformably to,	Laut des Befehles, According to the order. Laut des Briefes, According to the letter. Laut der Urkunde, Conformably with the document.
Längs (1, 2),	along,	Sie marschirten längs dem Ufer, They marched along the shore.
Mittelst (1),	by means of,	Mittelst der Rettungsböte, By means of the lifeboats.
Mit (2),	with,	Mit seiner Mutter oder seinem Vater, With his mother or father.
Nach (2),	after, to,	Ich gehe jeden Tag nach Hamburg, I go to Hamburg every day.
Nächst (2),	next to,	Er sitzt nächst seinem Bruder, He sits next to his brother.
Neben (4),	near, at the side of,	Der König setzte sich neben die Königin, The king seated himself near the queen.
Nebst (2),	together with,	Nebst etwas Geld, A letter with some money.
Oberhalb (1),	on the upper side of,	Wir standen oberhalb des Flusses und der Feind stand unterhalb des Hugels, We stood *above* the river and the enemy *below* the hill.
Ohne (3),	without,	Ohne Wissen ihrer Verwandten, Without the knowledge of her relations.
Sammt (2),	together with,	Er floh sammt Frau und Kindern, He fled with wife and children.
Seit (2),	since (of time),	Seit seiner Ankunft, Since his arrival. Seit zwei Jahren, For two years. Seitdem, Since then.
Sonder (3),	without (used in a few phrases only),	Sonder Zweifel, sonder Mühe, Without doubt, without trouble.
Trotz (1),	in spite of,	Trotz alles Widerstandes, In spite of all opposition.
Uber (4),	over, through,	Uber dir hängt eine schwarze Wolke, A black cloud hangs over thee. Wir sind gestern über die Brücke geritten, We rode yesterday over the bridge.
Um (3),	round,	Ich bitte (Sie) um Verzeihung, I beg your pardon.
Ungeachtet (1),	notwithstanding,	Ungeachtet des schlechten Wetters, Notwithstanding the bad weather.
Unter (4),	under, beneath,	Er ist unter den Tisch gekrochen, He has crept under the table. Das Boot blieb unter der Brücke, The boat remained under the bridge.
Unterhalb (1),	below, on the lower side of,	Unterhalb der Brücke, Below the bridge (see Oberhalb).
Unweit (1),	near, not far from,	Eine große Schlacht wurde unweit Brüssel geliefert, A great battle was fought not far from Brussels.
Vermöge (1),	by virtue of,	Vermöge seiner Thätigkeit, By means of his activity.
Vermittelst (1),	by means of,	Vermittelst Ihres Beistandes, By (means of) your assistance.

GERMAN PREPOSITIONS (*Continued*).

Prepositions.	Significations.	Examples.
Von (2),	from, of,	Die Zeitung von vorgestern, The day before yesterday's paper. Wir sind vom Regen naß geworden, We have been drenched with the rain.
Vor (4),	before, ago,	Wie lange sind die Truppen vor dem Thore geblieben? How long have the troops been before the gate? Er warf das Buch vor mich hin, He threw down the book before me.
Während (1),	during,	Während seines Aufenthalts in Italien, During his stay in Italy.
Wegen (1),	on account of,	Seines Alters wegen, On account of his age.
Wider (3),	against,	Verschwor er sich wider den Konig? Did he conspire against the king?
Zu (2),	to, at, by,	Zu Lande oder zur See, By land or sea. Zur Hochzeit gehen, To go to the wedding.
Zufolge (1, 2),	in consequence of (1, before the noun with the gen.; and 2, after the noun with the dat.),	Zufolge des Befehles; dem Befehle zufolge, In consequence of the order. Zufolge seines Briefes (or seinem Briefe zufolge) wird er morgen hier seyn, According to his letter he will be here to-morrow.
Zuwider (2),	against (placed after its noun),	Meinem Willen zuwider (or entgegen), Contrary to my will.
Zwischen (4),	between,	Er fiel zwischen die Räder, He fell between the wheels. Zwischen den Türken und Russen, Between the Turks and the Russians.

For the sake of ease in the recollection of the proper cases which these prepositions govern the Germans have thrown them into the following mnemonic lines for each of the four classes in the foregoing lists, which the student should commit to memory, viz.:—

(1) Prepositions governing the genitive—

unweit, mittels, kraft, und während,
laut, vermöge, ungeachtet,
oberhalb und unterhalb,
innerhalb und außerhalb,
diesseits, jenseits, halben, wegen,
anstatt, längs, zufolge, trotz.

The three last, however, may also be used before the dative.

(2) Prepositions governing the dative—

mit, nach, nächst, nebst, sammt,
bei, seit, von, zu, zuwider,
entgegen, außer, aus.

(3) Prepositions governing the accusative—

durch, für, ohne, um,
sonder, gegen, wider.

(4) Prepositions governing both dative and accusative—

an, auf, hinter, neben, in,
über, unter, vor und zwischen.

The dative is used in a question put by wo? and the accusative in one put by wohin?

In the immediately foregoing list the German prepositions are given with, as nearly as possible, their primitive meaning, lest the introduction here of their numerous and often diverse derivative significations might confuse the beginner. In the examples we have chosen as illustrative of their use we have not, however, confined ourselves to instances in which German and English are merely convertible or interchangeable. This has the double advantage of at once showing the real force of the preposition and of stimulating the learner to ask himself through what conception of space that special idea of relation has been reached.

A considerable number of substantive, participial, and adverbial phrases have by usage acquired the force and meaning of prepositions. These may often be recognized by their form, even when they are admitted, as some of them, *e.g.* anstatt, diesseits, kraft, ungeachtet, während, &c., have been in the foregoing list of ordinary prepositions. They generally indicate place, time, and cause, even more precisely than the simpler and normal prepositions. Indeed, it is mainly owing to the variety of significations which may possibly be indicated by what may be called the older and customary particles of relation, that these other and more modern modes of localization, particularly in reference to intellectual relations, have been found necessary. The idea of union is suggested by neben, nebst, and sammt; time is referred to by seit, während, binnen, and bis; cause and effect have gemaß, halben, kraft, laut, um=willen, vermittelst, vermöge, zufolge employed to indicate them; adverse act or intent is shown by gegen, trotz, and ungeachtet; negation or exclusion is suggested by ohne and the seldom-used sonder, and local direction (real or ideal) by most of the others, as the opposites of height on and over, auf and uber; and lowness unter. Within an inclosed space has in, and just out of such a space is expressed by aus, while entirely outside of it takes außer; hinter and vor are the direct opposites of place behind and in front of an object or inclosure; durch is through, in the direction from without inward; um means round or about, encircling an object or place; mit implies connection among objects, and community of action, purpose, or interest among persons. Gegen expresses a relation towards a person generally (either in favour of or against); wider implies unfavourable resistance, and für action in favour of another intentionally; von denotes direction from which, nach and zu direction to which (sometimes as an opposite to von).

These instances will, we hope, serve to indicate how, by analogy, these prepositions acquire and pass through a considerable gradation of meaning. But for greater helpfulness we shall add a few remarks on some of the more idiomatic usages of a few of the more difficult prepositions.

The three prepositions längs, along; zufolge, in consequence of; and trotz, in spite of, govern the genitive and dative indiscriminately, as längs dem Flusse or längs des Flusses, along the river; zufolge des Vertrages or zufolge dem Vertrage, in consequence of the treaty; trotz seinen verbindlichkeiten or trotz seiner verbindlichkeiten, in spite of his engagements.

As regards the prepositions in class 4 which sometimes govern the dative and sometimes the accusative, the rule is that when a preposition indicates movement *from* a place, or *no* movement at all, it governs the dative, as ich komme aus dem Garten, I am coming out of the garden; ich bin in dem Garten, I am in the garden; unter dem Tische liegen, to lie under the table; but when it indicates *to* a place, it governs the accusative, as ich gehe in den Garten, I am going into the garden; stelle dich unter den Baum, place yourself under the tree.

The prepositions zu and nach, however, though they indicate a movement *to* a place, always have the dative. The preposition um always governs the accusative case of a noun, even when it indicates no movement at all. The adverb her is often used along with um after a noun or pronoun, as Alle standen um uns her, all were standing around us.

Halben is used with pronouns; as meinethalben, on my account; unserthalben, on our account, &c. It occurs in an abbreviated form in deßhalb, on that account, weßhalb, on which account, &c.; and also in the following four compound opposite pairs of prepositions:—außerhalb, without (on the outside of); innerhalb, within (in the inner part of); ober=halb, above (on the upper side of); unterhalb, below (on the lower side of).

Von is used before the name of any material of which a thing is made: von Holz, made of wood.

The proper names of countries, places, islands, and months, when preceded by their common names, have not the preposition *of* placed before them; as das Königreich Preußen,

the kingdom [of] Prussia; die Stadt Berlin, the city [of] Berlin; der Monat März, the month [of] March.

Before names of countries, places, &c., the prepositions for and to are translated by nach; at or in by in; from by von; and of, when signifying near, by bei; as Er geht nach München, he goes to (starts for) Munich; Ich komme von Mecheln, I come from Malines; Er ist in Aachen, he is at Aix-la-Chapelle; Die Schlacht bei Königstein, the battle of Konigstein.

Zu is used with names of cities only when personal employments are spoken of; as Er studirt zu Heidelberg, he studies at Heidelberg; otherwise the preposition in is used; as In Genoa sind die Nächte kühl, in Genoa the nights are cool.

Zu has been used with names of things so commonly as to have formed many adverbial phrases; as zu Bette, to bed, zu Tische, to dinner, zur Schule, to school, zu Schiffe, on board ship: *e.g.* Bringe ihn zu Bette, put him to bed; Er geht zur Schule, he [is of such an age that he] goes to school. He actually attends school is expressed by in with the accusative, as Ich gehe in die Schule, I go to school.

"By," before the name of an author, is translated by von; and "in," or "in the works of," is translated by bei; as Die Räuber von Schiller, "The Robbers," by Schiller; Bei Homer, in Homer, *i.e.* in Homer's works.

For längs, along, it is more usual to say entlang. The former stands before, the latter after, the dative: as Längs dem Flusse or dem Flusse entlang, along the river.

Prepositions are very commonly contracted with the definite article, with pronouns, or with adverbs, so as to form a compound word.

The prepositions most commonly contracted with the definite article are:—(1) an, in, von, zu, are contracted with dem, to the, and form am, im, vom, zum; as am Brunnen, at the well; (2) an, auf, durch, für, in, über, unter, vor, are contracted with das, so as to form ans, aufs, durchs, &c.; as ins Wasser, into the water; (3) zu is contracted with der, to the; as zur Mutter, to the mother.

The following adverbs partake of the nature of prepositions, and take the genitive, viz.—hinsichts, hinsichtlich, rücksichtlich, with regard to; angesichts, in the face of, in the presence of; behufs, on behalf of; inmitten, in the midst of; unbeschadet, without prejudice to.

The adverbs da, hier, wo, are often joined to prepositions, and are thus used to replace the neuter form of the demonstrative, relative, or interrogative pronouns; as Ich bin damit zufrieden, I am contented therewith (or with it); Wovon sprechen Sie? Whereof (*i.e.* of what) do you speak?

PREPOSITIONS USED IN COMPOUND VERBS—SEPARABLE AND INSEPARABLE.

Certain parts of speech, chiefly prepositions, frequently adverbs, and sometimes other particles, are used in combination with particular verbs, in such a manner that the two words together have only one meaning, and are in some other languages represented by a simple word; for instance—German, Ich gehe aus; English, *I go out;* French, *je sors.*

The particles be, ent or emp, er, ge, miß, ver, voll, zer, hinter, and wider serve to modify the sense of the simple verbs to which they are prefixed.

Be denotes some extension of an action over an object, or the communication of an action or condition to another; as beschmieren, to besmear; besprechen, to speak about, to discuss.

Ent and emp denote removal from and approximation to a thing; as entnehmen, to take away; entbehren, to want.

Er denotes obtaining, effecting, coming into a condition, &c.; as erhalten, to receive; erfechten, to obtain by fighting; erblinden, to grow blind.

Ge denotes the imparting of some intenseness to an action or a condition; as gedenken, to think; sich gedulden, to endure.

Miß has the same force as the English "mis" or "dis;" as mißfallen, to displease; mißbrauchen, to misuse.

Ver denotes removal from a place, or the deprivation of an original condition; as verpflanzen, to transplant; vergessen, to forget; verwirren, to confound.

Voll expresses completion; as vollbringen, to accomplish.

Zer denotes the dissociation of the several parts of a thing; as zerschneiden, to cut in pieces; zerrinnen, to melt away.

Compound verbs are known as (1) inseparable, and (2) separable. The latter, although really easily mastered, present one of the most puzzling obstacles the beginner has to face in reading, because the *separable* particles are frequently capable of being used as independent words; so that when the beginner meets them in a sentence he may be puzzled as to whether they are independent or are part of a verb of which the other part is to be found elsewhere in the sentence.

(1) The general rule is that those compound verbs are inseparable which have the accent on the verb, and not on the prefixed word. Of this kind are many verbs which are compounded with the prepositions über (überlegen, to reflect), um (umnebeln, to surround with mist), wieder (wiederholen, to repeat), and all verbs which begin with the inseparable particles.

The past participle of inseparable compound verbs does not prefix the augmentative ge; as übersetzen, to translate; übersetzt, translated. The following verbs, because they have the accent on the prefixed word, are, however, conjugated in the regular way:—gerechtfertigt, justified; geantwortet, answered; geliebkost, caressed; gefrühstückt, breakfasted; geurtheilt, judged; gerathschlagt, deliberated; geweissagt, foretold; gewillfahrt, gratified.

The following are among the inseparable compound verbs which are most in use:—

hinterlassen,	to leave behind.	unterzeichnen,	to subscribe.
hintergehen,	to deceive.	überdenken,	to ponder.
hintertreiben,	to frustrate.	übergeben,	to surrender.
unterbleiben,	to be omitted.	überlassen,	to leave.
unterbrechen,	to interrupt.	überleben,	to survive.
unterdrücken,	to suppress.	überlegen,	to consider.
unterhandeln,	to treat.	übernehmen,	to take upon oneself.
unterlassen,	to omit.		
unterliegen,	to succumb.	überschreiten,	to transgress.
unternehmen,	to undertake.	überwinden,	to conquer.
unterrichten,	to instruct.	überzeugen,	to persuade.
untersagen,	to interdict.	umarmen,	to embrace.
unterscheiden,	to distinguish.	umgeben,	to surround.
unterstützen,	to assist.	umhüllen,	to envelop.

vollbringen, vollenden, vollziehen, to fulfil or to accomplish.

(2) In the separable compound verbs the prefix can be disjoined from the simple verb and placed, like an adverb, after the verb. Of this kind are all verbs which begin with the prepositions (or adverbs) ab, an, auf, aus, bei, dar, ein, fort, her, hin, los, mit, nach, nieder, ob, vor, weg, zu. The accent of these verbs is always on the prefixed word; as vo'rstellen, we'gschicken, &c. In the present and imperfect indicative, and in the imperative and interrogative moods, these particles are separated from the verb and placed at the end of the clause; as Wann fängt er an? When does he begin? Schicke ihn weg, Send him away; Sie schlossen die Thüre zu, They shut the door. These prefixes are not separated from the verb in the participles, the infinitive, and in those tenses compounded with the infinitive (*i.e.* future and conditional); as Ich werde anfangen, I shall begin; but in the participle the usual prefix ge is placed between the verb and its particle; as angefangen, begun, weggeschickt, sent away.

The following compound verbs require particular attention on account of their being sometimes separable, sometimes inseparable, according to the difference of their accent and meaning.

SEPARABLE.		INSEPARABLE.	
du'rchfahren,	to drive through.	durchfa'hren,	to pierce.
hi'nterbringen,	to bring behind.	hinterbri'ngen,	to advise.
ü'bersetzen,	to put over.	überse'tzen,	to translate.
u'nterschreiben,	to write under.	unterschrei'ben,	to subscribe.
u'nterhalten,	to hold under.	unterha'lten,	to entertain.
ü'berlaufen,	to flow (run) over.	überlau'fen,	to importune.
ü'berführen,	to conduct over.	überfü'hren,	to convince.
ü'bertreten,	to tread over.	übertre'ten,	to transgress.
wie'derholen,	to fetch back.	wiederho'len,	to repeat.

EASY LESSONS IN READING.

In the two following simple lessons in reading we supply (1) text, in which the number placed after each word shows

the place which that word occupies in the English translation; (2) translation (literally accurate and word for word); and (3) a few notes explanatory of difficult words:—

Der Knabe und der Schmetterling.

Ein[1] Knabe,[2] welcher[3] in[5] einem[6] Garten[7] spatzieren[4] ging,[4] einen[9] Schmetterling[10] bemerkte;[8] und[11] von[13] der[14] Schönheit[15] seiner[16] Farben[17] angezogen,[12] begann[19] er,[18] ihn[21] zu[20] verfolgen.[20] Der[1] Flüchtling[2] entging[3] lange[4] der[5] Behendigkeit[6] seines[7] Verfolgers;[8] endlich[9] flog[12] er[11] aber[10] in[13] den[14] Kelch[15] einer[16] Tulpe,[17] um[18] sich[18] auszuruhen,[18] und[19] die[21] Süßigkeit[22] dieser[23] Blume[24] einzusaugen.[20] Der[1] Knabe[2] lief[5] nun[3] hitzig[4] hinzu,[5] und[6] sicherte[11] mit[7] einem[8] heftigen[9] Griff[10] den[12] Gefangenen,[13] zerquetschte[16] aber[14] zugleich[15] seine[17] zarten[18] Flügel.[19] Auf[3] diese[4] Art[5] wurde[6] die[1] Eroberung[2] nutzlos,[7] und[8] der[9] Genuß,[10] welcher[11] von[13] dem[14] Besitz[15] erwartet[12] worden,[11] war[16] zerstört.[17] Das[1] Vergnügen[1] in[2] der[3] sittlichen[4] Welt,[5] ist[6] jenem[8] Schmetterlinge[9] ähnlich:[7] es[10] zieht[11] uns[12] an,[11] während[11] wir[14] demselben[16] nachgehen;[15] wenn[18] wir[19] es[21] aber[17] mit[22] zu[23] großer[24] Begierde[25] ergreifen[20] wird[27] es[26] zerstört,[28] ehe[29] wir[30] es[33] genießen[32] können.[31]

The Boy and the Butterfly.

A boy, who was walking (*a*) in a garden, noticed a butterfly; and, attracted by the beauty of its colours, began to pursue it. The fugitive eluded for a long time the activity of his pursuer; at last, however, it entered into the cup of a tulip to repose (*b*), and to sip the sweetness of that flower. The boy now eagerly ran forward (*c*), and, with a violent grasp, secured the prisoner; but, at the same time, crushed (*d*) its delicate wings. The conquest in this way became useless, and the gratification, which had been expected from the possession, was destroyed. Pleasure in the moral world is like that butterfly; it attracts (*e*) us while we pursue it; but if we seize it with too much ardour, it is destroyed before we can enjoy it.

(*a*) Gehen spatzieren, to take a leisurely walk for pleasure, to saunter.

(*b*) Um is used before the infinitive with zu (which in German takes the place of a supine) to indicate purpose, intention, or design. This phrase is therefore equivalent to "with the intention of gaining rest to itself."

(*c*) Hinzu-laufen is a compound verb having as its elements the separable adverb hinzu, to, towards, near, forward, &c., proceeding from a point, the opposite of heran, also meaning to, towards, near, forward, &c., but approaching to a point, and the irregular verb laufen, lief, gelaufen, to run. In such verbs, the prefix may be separated, in independent phrases, from the simple verb, and be placed, like an adverb, after the verb.

(*d*) Zerquetschen is compounded of the inseparable unaccented particle zer, denoting dispersion and destruction, and the regular active verb quetschen, to crush or bruise. It means crushed so as to spoil and destroy. See also below zer-stören, from stören, to trouble.

(*e*) Anziehen, compounded of the separable preposition an, to, towards, &c., and the irregular active verb ziehen, zog, gezogen, to draw, attract.

Guter Rath.

Als[1] Dr.[2] Doddrige[3] seine[5] kleine[6] Tochter,[7] welche[8] früh[10] starb,[9] fragte,[4] wie[11] es[12] komme,[13] daß[14] Jeder[15] sie[19] zu[17] lieben[18] scheine?[16] antwortete[21] sie:[20] „Ich[22] weiß[23] es[24] nicht,[25] wenn-[26] nicht[26] daher,[27] daß[28] ich[29] Jeden[31] liebe."[30] Dieß[1] war[2] nicht[3] allein[4] eine[5] überraschende,[6] sondern[7] zugleich[8] eine[7] kluge[10] Antwort.[11] Der[1] einzige[2] Weg[3] geliebt[6] zu[4] werden,[5] ist[7] liebenswürdig[13] zu[8] sein[9] und[10] zu[11] scheinen:[12] Güte,[19] Wohlwollen,[20] Zartgefühl[21] zu[14] besitzen[15] und[16] zu[17] beweisen,[18] frei[24] zu[22] sein[23] von[25] Selbstsucht,[26] Theil[29] zu[27] nehmen[28] an[30] dem[31] Wohlergehen[32] Anderer.[33]

Good Advice.

When Dr. Doddridge asked his little daughter, who died early, how it came that everybody seemed to love her, she answered: "I know (it) not, unless because that I love everybody." This was not only a startling but also a sensible reply. The only way to be loved is to be and appear lovely; to possess and to show kindness, benevolence, tenderness; to be free from selfishness, to take interest in the welfare of others.

To make these simple lessons really valuable the student is recommended (1) to read the text and translations over word by word so as to make himself thoroughly acquainted with the exact equivalents in each language, and thus enrich his vocabulary; (2) to observe the order of the words, and especially to notice in what manner that order differs in German and English, as an aid towards using similar forms when required hereafter; (3) to endeavour to trace, by reference to the lessons given on these subjects, (i.) the cases, numbers, genders, and form of declension of each noun, adjective, and pronoun; (ii.) the numbers, persons, tenses, and, as far as possible, moods of verbs—especially in the case of irregular verbs, learning their chief parts and their usual signification; (4) to pay particular attention to the prepositions employed in these lessons, the meanings they have, the cases they govern, and the place they occupy. A few words—adverbs and conjunctions—if attended to now, will enable the learner to understand better the specific grammatical instruction in those parts of speech yet to be given. (5) Having succeeded in seeing the correlation of word to word in each language, the text in one language should be covered with a card, and read off from the one into the version given in the covered column.

Imitative Exercise in Sentence-making.

In the following simple exercise the word between the dashes is to be replaced by one of the words given in the vocabulary below:—

Um Geschäfts willen lernte ich die—deutsche—Sprache, For the sake of business I learned the—German—language. Lernen Sie die—deutsche—Sprache? Do you learn the—German—language? Was denken Sie von der—deutschen—Sprache? What do you think of the—German—language? Lassen Sie uns—Deutsch—sprechen, Let us speak—German.

französische,	French.	russische,	Russian.
englische,	English.	türkische,	Turkish.
spanische,	Spanish.	griechische,	Greek.
dänische,	Danish.	italienische,	Italian.
schwedische,	Swedish.	ungarische,	Hungarian.

Introduce, instead of Taschentuch, the nouns given in the following vocabulary, one after the other, into the sentence:—

Ich habe Ihr—Taschentuch—gefunden, I have found your—pocket-handkerchief.

Ohrgehänge,	earrings.	Teller,	plate.
Halsband,	collar.	Schüssel,	dish.
Armband,	cuff.	Tasse,	cup.
Ring,	ring.	Flasche,	bottle.
Fächer,	fan.	Glas,	glass.
Sonnenschirm,	parasol.	Messer,	knife.
Regenschirm,	umbrella.	Gabel,	fork.
Spiegel,	looking-glass.	Löffel,	spoon.

Replace the noun Tugend by (1) one of the following nouns; (2) by two of them joined together by und; and (3) by any three of them, &c.—

Wir müssen immer sorgfältig sein die—Tugend—zu ehren, We must always be careful to honour—virtue.

Frömmigkeit,	piety.	Gerechtigkeit,	justice.
Güte,	goodness.	Freigebigkeit,	liberality.
Muth,	courage.	Großmuth,	magnanimity.
Tapferkeit,	bravery.	Ehrbarkeit,	honesty.
Kühnheit,	boldness.	Wahrheit,	truth.

Substitute for the word Geld any of the other words given below, and any other suitable word from the above lists—

Er ging um sein—Geld—zu bekommen, He went in order to get his—money.

Koffer,	trunk.	Lohn,	reward.
Nachtsack,	carpet-bag.	Lehrer,	teacher.
Mantelsack,	portmanteau.	Blume,	flower.
Bruder,	brother.	Feder,	pen.
Kahn,	boat.	Börse,	purse.

Instead of England and Deutschland introduce the names of the places given below into the following sentences:—

Wann gehen Sie nach—England? When do you go to—England? Wie lange sind Sie in—Deutschland—gewesen? How long have you been in—Germany?

Replace Buch in the following sentence with one of those words given below; alter the translation to suit, and continue till all are used:—

Haben Sie das—Buch—gelesen, welches ich Ihnen schickte? Have you read the—book—which I sent you?

Australien,	Australia.	Billet,	note.
Baiern,	Bavaria.	Brieftasche,	portfolio.
Frankreich,	France.	Circular,	circular.
Griechenland,	Greece.	Entwurf,	draft.
Schweden,	Sweden.	Privat-brief,	private letter.
Schweiz,	Switzerland.	Postscript,	postscript.
Spanien,	Spain.		
Rußland,	Russia.		

ENGLISH GRAMMAR AND COMPOSITION.—CHAPTER IX.

SYNTAX—SENTENCES: THEIR ELEMENTS, STRUCTURE, AND LAWS.

Etymology defines and classifies words as (1) derivatives one from another, and (2) as performing special duties in the formation of sentences. Accidence explains, records, and exhibits the several changes to which words are (or may be) subjected, to fit them to fill their place, and fulfil their function in the construction of sentences which express thought or emotion. Syntax arranges words in due and proper order, in such relations one to another as shall most correctly and effectively secure the accurate transfer of thought from mind to mind. Syntax is not a body of arbitrary laws ordained by some mysterious authority of which grammarians are the expositors and enforcers, and which is inexorably and unchangingly fixed for ever by some independent fiat of some supreme power, individual or collective. Syntax is really the carefully collected inductive observations of thoughtful students, who have made researches into the usages of the best writers and speakers of a language, and recorded the results of their laborious and watchful collations of the forms of phrase, idiom, and sentence employed by the master-minds who have used speech with success and charmingness. These notes of observant men have gradually assumed the form of a series of concise statements of the principles which appear to them to exercise influence, consciously or unconsciously, in the minds of those who most effectively employ language in speaking and writing. They see that in all those sentences which most successfully convey thought, words are found to occupy certain places, to enter into special relations, and even to undergo peculiar changes of form, in order that they may the more distinctly and explicitly express what is intended. These notes and statements made regarding the arrangements and adaptations of words in sentences have in their collective form become embodied into a division of grammar bearing the name of *Syntax*, and treating of the grammatical relations of words one to another in the expression of thought. The main duty of logic is to regulate thought, and that of grammar is to regulate the expression of thought. Thus logic ought to secure to us, if not absolutely correct, at least thoroughly consistent, thought; but grammar should show us how to attain to consistent expression—for all inconsistent expressions are in reality incorrect. Grammar therefore assumes that correct, or at least definite, thought has been attained, and that a felt necessity has arisen for its utterance. What we thus discern in our minds, and desire that others should perceive in theirs, we set forth in a proposition or sentence.

Any combination of words conveying complete sense constitutes *a sentence*. Sentences may (1) indicate our feelings, emotions, impressions, experiences, opinions, thoughts, &c.; (2) interrogate others in regard to their physical, mental, or moral feelings, emotions, &c.; or (3) express our desire, wish, entreaty, exhortation, or command to others in relation to their feelings, emotions, &c. Sentences which simply make statements are *Indicative;* which ask questions, *Interrogative;* and which are intended to influence the will of, and be equivalent to commands to others, *Imperative.* The simplest complete forms in which these sentences can appear may be seen in the following examples—John speaks (Indicative). Does John speak? (Interrogative). Speak, John (Imperative).

Every sentence, when regarded as a *logical* statement or expression, consists of three distinct parts, viz. (1) the *subject*, or that which is brought under the view or review of the mind; (2) the *predicate*, or that which the mind is prepared to state concerning the subject; and (3) the *copula*, *i.e.* some tie or link which informs us that these two parts are to be thought of together, and in some special relation to one another. Such statements as these are logical propositions:—

Subject.	Copula.	Predicate.
The earth	is	a globe.
The empire	is	peace.
The sun	is	shining.
Geology	is	a science.
Planets	are	stars.
Opinion	is	omnipotence.
Errors	are	dangerous.
Anger	is	madness.
To err	is	human.
Whatever is	is	right.
Knowledge	is	power.

Many grammarians accept this arrangement as the normal form of thought, and found upon it a department of practical grammar, to which they give the name of "the logical analysis of sentences." To this, as an excellent mode of training the mind to the observant comparison of the thought implied with the words employed, no objection need be taken; but as regards the extension of logical *formulæ* into grammatical teaching some caution ought to be exercised. Logic merely regulates *reasoned* thought, but grammar regulates the expression of thought not under the influence of reason alone, but of feeling, interest, passion, &c.; and hence to compel the arrangement of all (possible) forms of expression on the Procrustes bed of the logical proposition, as the single and only types of a correct form of sentence, is to misuse that form, and unnecessarily to complicate the study of grammar with the processes of logic.

Grammar, while it adopts the terms *subject* and *predicate* from logic, employs them with a simpler usage which is peculiarly its own. In logic the *subject* may include the entire description of that which is the special matter of thought, and the *predicate* may consist of all that is said about it. For example—

Subject.	Copula.	Predicate.
That gaseous envelope which enwraps the earth, and extends at least 40 or 50 miles outwards from the surface of the globe, and perhaps in a gradually increasing degree of tenuity to a much greater height,	is	the atmosphere.
The atmosphere, geologically considered,	is	an agent of change by virtue of (1) its composition and the reactions which it effects; (2) its varying temperature and consequent influence in expanding and contracting rocks; and (3) its movements.

But in grammar, which treats of the grouping of single words into sentences expressive of what man desires to say, these terms are used in a much more restricted meaning. Though in the sentence, "On her accession to the English throne, Elizabeth, daughter of Henry VIII. and of Anne Boleyn—*was*—asked by Philip II. of Spain to become his wife," the whole of the matter preceding the copula *was* is the logical subject, and all that follows is the logical predicate, in grammar it is otherwise. *Elizabeth* is the gram-

matical subject; *was asked*, the predicate; and all the other words used are grouped around these as adjuncts, complements, &c.

The grammatical subject of a sentence is in its simplest form (1) a noun, or (2) some word or collection of words which are (or are taken to be) equivalent to a noun.

The grammatical predicate is in its simplest form (1) any finite part of the verb *to be*, (2) any verb, either taken (i.) by itself, or (ii.) with such words as are necessary to complete its signification. All other verbs, except *to be*, absorb the logical copula into them when used as predicates.

In every case it is the function or power of a word in a sentence, not its etymological place in any classification of words, which determines its character and syntactical relations; and it must be remembered that the supreme requirement of grammar is correctness, which implies consistency of expression. The subject and the predicate—that is, in point of fact, the noun and the verb—constitute the main elements of a sentence. All the other words in a sentence group themselves around, and attach themselves to, these two (or their equivalents). There can be no complete sentence without a subject and a predicate, though in certain circumstances either may be held as understood; *e.g.* we may have the imperative of a verb used alone, as *Go;* but that is really equivalent to *Go thou*, and the answer might be *No!* but that would signify *I will not go*. A complete sentence may be formed with no other words than (1) a noun as subject, and (2) a verb as predicate—as in the following instances:—

Subject.	Predicate.	Subject.	Predicate.	Subject.	Predicate.
Flowers	bloom.	Rain	falls.	Man	labours.
Oranges	grow.	Time	passes.	Groans	arise.
Masons	build.	Grief	subdues.	Joys	excite.
Forms	alter.	Lightning	flashes.	Winter	comes.

Sentences which, like those, consist of one subject and one predicate (or finite verb) are called *simple*.

Sentences which have two or more subjects or two or more predicates—*i.e.* composed of two or more simple sentences coordinately combined—are called *compound*.

Sentences which consist of two or more simple sentences so combined that one is dependent on or subordinated to another, are called *complex; e.g.* John runs, *simple;* John and Thomas run, Thomas runs and John leaps, *compound;* Thomas runs that he may gain a prize, but John leaps in sheer exuberance of animal spirits, *complex*.

We shall in the meantime consider simple sentences, with their possible adjuncts, complements, and modifications. These, as we know, may be either Indicative, Interrogative, or Imperative; *e.g.*

Indicative.	Interrogative.	Imperative.
Time flies.	Does time fly?	O time, fly.
Men judge.	Do men judge?	Judge, O men.
The girl reads.	Does the girl read?	Read, girl.
Alfred studies.	Does Alfred study?	Alfred, study.

In simple sentences, the *subject* may have as its equivalent

(1) A pronoun (which is the recognized substitute for a noun):

They err; *We* walk; *Ye* sleep; *I* rest; *Thou* yawnest.

(2) An adjective, used with the signification of a noun:

The *young* are often giddy; the *old*, critical.

(3) An infinitive verb used as a noun or name:

To walk is pleasant; *to swim* is delightful.

(4) A present participle (*i.e.* a gerund or verbal noun):

Reading maketh a full man; *parting* is sweet sorrow.

(5) A relative pronoun:

Who comes here? *What* do you want?

(6) A phrase (conveying a substantive meaning):

To make wars cease is worthy of effort.

(7) A quotation (which really means "the saying," &c.):

"I don't know" is no excuse.
"To be merry and wise" is a popular saying.
"Thou art the man!" was said by Nathan to David.

(8) The neuter pronoun *it*, and the adverb *there*. [This usage is rhetorical and pleonastic, and is employed chiefly when it is desirable to give emphasis to the subject by changing its normal position.]

It is better to be the fool than the unthrift of a family
(*i.e.* To be the fool of the family is better than to be its unthrift).
There are words which fly abroad like poisoned arrows
(*i.e.* Words fly abroad like poisoned arrows).
It is the spendthrift that wastes a spacious fortune.
There is nothing that disables a man so much as cowardice.

The *predicate* of a simple sentence may appear in the four following forms:—

(1) Some finite part of the verb *to be* with some supplementary attributive word attached to it:

Man *is mortal;* the bard *was grey-haired;* two *were green.*

(2) An intransitive or passive verb:

The lightning *flashed;* the earth *shook;* Cæsar *was slain.*

(3) A verb transitive having one direct complementary objective:

I *love him;* Bruce *stabbed Comyn;* Walter *flattered Mary.*

(4) A verb transitive having a double—*i.e.* a direct and an indirect—complementary objective:

The Romans *chose Cicero consul.*
Overwork *has made him ill.*
They *taught him grammar.*
Augustus *gave Tiberius power.*

The simple subject may be defined, qualified, modified, and thereby rendered more distinct amd explicit by

(1) An Article:

A storm arose. *The* waves were hushed.

(2) A demonstrative pronoun:

These are the survivors; *that* is the last of them.

(3) A noun in apposition:

Cicero, *the orator*, was assassinated.

(4) A noun in the possessive case, (i.) with an apostrophe and *s* ('s):

Froude's Cæsar is interesting.

(ii.) With the preposition *of:*

The *works of Homer* are still unequalled.

(5) An adjective:

A *merry* heart doeth good like a medicine.

(6) A phrase equivalent to an adjective:

A word *of caution* (= a warning word) is frequently useful.
Adorned with wisdom, she was beautiful and good.
Born to empire, he was humble of spirit.
His thirst *for fame* misled him to his ruin.
Adam *here* will go my message.
I *only* (= alone) have been to blame.

The *predicate* may be variously modified. In the first instance, where the copula is unabsorbed and a noun is used after some finite part of the verb *to be*, that noun may be qualified by

(1) An adjective (or more than one if requisite):

Alfred was a *good* (*learned* and *wise*) sovereign.

(2) A noun (or pronoun) in the possessive case—either apostrophe and *s* ('s) or prepositional:

Henry Lawes was *Milton's* friend. Milton was the secretary *of Oliver Cromwell.*

Carlyle was a writer *of great ability*. It is *his* best style.

(3) An adverb may be used to qualify any adjective employed:

The elephant's trunk is enormously large and heavy.

In the second instance, where an attributive adjective is joined with a part of the verb *to be* as a predicate, (1) an

adverb or (2) an abverbial phrase may be used to qualify the adjective :

Montaigne is exceedingly garrulous.

Milton is in many respects surpassingly grand.

In this way sentences may be enlarged and modified to a very considerable extent in either or both of their chief parts :

John wrote. John Milton wrote. The famous John Milton wrote. The famous John Milton, author of "Paradise Lost," wrote. The famous John Milton, author of that noble poem "Paradise Lost," wrote. The famous John Milton, author of that noble epic poem "Paradise Lost," wrote. The justly famous John Milton, author of that matchlessly noble poem "Paradise Lost," wrote—and so on, adding new specific modifications to *the subject*, so far as may be considered necessary or desirable.

In the same way the predicate may be made more and more precise and minute ; *e.g.*

Milton wrote works. Milton wrote many works. Milton wrote many other works. Milton wrote many other excellent works. Milton wrote many other excellent works in prose. Milton wrote many other most excellent works in prose. Milton wrote many other most excellent works in prose and verse. Milton wrote many other most excellent works both in prose and verse. Milton wrote, notwithstanding his failing eyesight, many other most excellent works both in prose and verse. Milton wrote, notwithstanding his fast-failing eyesight, many most excellent works both in prose and verse. Milton wrote, notwithstanding his fast-failing eyesight and ultimate blindness, many other most excellent works in prose and verse. Milton wrote, notwithstanding his fast-failing eyesight and ultimate total blindness, many other most excellent works in spirit-stirring prose and splendid verse. Milton wrote, with masterly self-possession, notwithstanding his fast-failing eyesight, many other most excellent works in earnest spirit-stirring prose and splendidly sonorous verse, &c., &c.

The previous forms of the subject may next be read in conjunction with those of the predicate just given into a series of sentences regularly increasing in complexity : *e.g.*

The famous John Milton, author of that noble epic poem the "Paradise Lost," wrote many other most excellent works both in prose and verse; and so on.

Exercises.—The student may employ himself advantageously in constructing similarly increasing sentences on any topic with which he may happen to be best acquainted, *e.g.* the steam-engine.

The steam-engine was improved. The small workable model of a *steam-engine* used by Dr. Robison, professor of natural philosophy, in 1765, in his classes in the Glasgow University, when out of order, being brought under the notice of the celebrated James Watt, a man of genius and mechanical skill, born in Greenock, but then resident in Glasgow, *was improved* in every part by his fertile inventiveness, his practical mind, and his persevering intensity of spirit, into a satisfactory agent for useful and profitable employment in manufacturing and industrial pursuits.

The following list, which is purposely very miscellaneous, may suggest topics for such simple but extended sentences:—

The sea-shore. Home. Napoleon. Bravery. Slander. News. Art. Negligence. The sky. A ship. Fire. A statue. Wealth. The railway train. The mason. A bee. Coal. Herbs. Cities. Poetry. Fairy-land. Stephenson. Sir Thomas More. Disease. Straw. The window. Moss. Oranges. Water. Cylinder. Rivers. Grass.

A more formal and simple phase might suit in some cases better, and therefore we supply several forms to be used as models. This is one grammatically arranged :—

Infinitive	Art.	Noun.	Prep.	Art.	Noun.	Verb	Adjective.
To spend	a	holiday	in	the	country	is	pleasant.
To work	a	{sewing machine}	during	the	night	is	disagreeable.
To lend	a	book	to	a	student	is	serviceable.

To this kind of sentence we may give a different turn by using the rhetorical nominative *It*:—

Pron.	Verb.	Adjective.	Infinitive.	Art.	Noun.	Prep.	Art.	Noun.
It	is	pleasant	to spend	a	holiday	in	the	country.

The following arrangement exhibits the subject and the predicate, and the parts of speech of which each is made up:—

Subject.			Predicate.				
Noun.	Adverb.	Parti.	Verb.	Art.	Noun.	Pre	Noun.
Pleasure	immoderately	pursued	wastes	the	power	of	enjoyment
Debts	unnecessarily	incurred	burden	the	{after years}	of	life.
Gains	unjustly	acquired	lessen	the	joys	of	men.

It will often be found advantageous to select a sentence which strikes the mind as being felicitously expressed, and to endeavour to imitate it with other factors :—

Subject.		Predicate.			Enlargement.	
Pron.	Noun.	Aux.Verb.	Adv.	Verb.	Prep.	Noun.
This	negligence	did	not	proceed	from	indifference.
This	effort	did	not	result	in	success.
His	suggestion	was	not	accepted	with	pleasure.

Subject.			Predicate.			Enlargement.			
Art.	Adj.	Noun.	Ve.	Art.	Noun.	Pr	Art.	Noun.	Noun.
A	good	man	is	a	prince	of	the	Almighty's	creation
A	wise	merchant	is	an	increaser	of	the	country's	wealth
The	highest	benefactor	is	the	inspirer	of	the	people's	intellect

Not less, but even more beneficial, is that form of observant examination found, which takes a series of sentences, and while distinguishing subject and predicate, discriminates the several parts of speech just as they occur. For this purpose, the underlining of the subject by a double horizontal stroke, which we denote by printing in small capitals, and the predicate with a single one, which we denote by printing in italics, and the use of the nine digits to indicate the parts of speech in order, will be sufficient ; *e.g.*

2 5 4 7 1 3 2 7 1 2 7 2
COMPANY *is one of the* greatest *pleasures* of the nature of man.—
Thomas Fuller, D.D.

4 5 1 3 2 5 1 3 2
IT *is a* common *prejudice* TO-DESPISE THE PRESENT [time].—
Bishop Berkeley.

6 5 4 3 3 2 6 5 7
Here *is* one vast arched WINDOW, beautifully darkened with
3 2 7 3 2
divers scutcheons of painted glass.—*Alexander Pope.*

6 6 5 1 3 7 2 7 1 2 1
How gravely *move* the largest of LAND-CREATURES on the banks of
4 3 2
this fair river!—*Lord Shaftesbury* (1670–1713).

6 5 2 7 1 3 2 7 4 3
There *is* SILENCE on the tall mountain-peak with its glittering
2 7 2
mantle of snow.—*Hugh Miller.*

7 3 2 2 5 5 1 2 7 2
In former times, LAWS *used-to-be-made* to-fix the wages of labour.
—*Archbishop Whately.*

It is also a good mode of exercising the mind in the construction of sentences to endeavour to change the form of sentences:—

ROBERT *looks* me straight in the face (*Indicative*). *Does* ROBERT *look* me straight in the face? or *Is* ROBERT *looking* me straight in the face? (*Interrogative*). *Look* [THOU] me straight in the face, ROBERT (*Imperative*).

THIS *gives* us a glimpse of what their glory would be (*Indicative*). Does this give us a glimpse of what their glory would be? (*Interrogative*). How does this give us a glimpse of what their glory would be! (*Exclamatory*). Give us this glimpse of what their glory would be (*Imperative*).

The CARPENTER *mends* the leg of this table. Does the carpenter mend the leg of this table? Is the carpenter mending the leg of this table? Carpenter, mend, &c. How the carpenter mends! &c. How does the carpenter mend? &c. Tell the carpenter to mend, &c.

HEAVEN *flows* upon the soul in many dreams of high desire. Does heaven flow? &c. Heaven, flow, &c. How heaven flows! &c.

Again, taking such a sentence as the preceding, the student who wishes to acquire the power of moulding sentences into various forms so as to have a choice and to secure variety,

may with benefit to his style learn to transpose its terms while preserving its meaning; *e.g.*

> Heaven flows upon the soul in many dreams of high desire.
> —*Tennyson.*

> Upon the soul, in many dreams of high desire, heaven flows.
> In many dreams of high desire, heaven flows upon the soul.

It will be at once seen that if we alter these same words so as to read thus—

> Upon the soul of high desire, in many dreams, heaven flows,

we change the sense, and restrict its signification from a universal to a special inspiration.

Again, suppose we take the terms—

> "Thought takes a charm from the envesturing word,

we might transpose them into—

> From the envesturing word thought takes a charm. A charm thought takes from the envesturing word. Thought takes from the envesturing word a charm. A charm from the envesturing word thought takes.

But we cannot properly say—

> The envesturing thought takes from the word a charm,

because it is the thought that is *envestured* by the word.

Let the student vary the following sentences in as many ways as he can, preserving the original meaning with sedulous care:—

> "A shady grove, a green pasture, a stream of fresh water, are sufficient to attract a colony of Arabs."—*Edward Gibbon.*
> "My brother's timeless death I seem to mourn."—*John Home.*
> "Work is the mission of man on this earth."—*Carlyle.*
> "Each of these topics needs a lecture for its development."—*W. E. Channing.*
> "A man may read a sermon, the best and most passionate that ever man preached, if he shall but enter into the sepulchres of kings."—*Jeremy Taylor.*

These exercises bring us within sight of the general principle on which grammarians insist, because they have observed that it is most carefully attended to by the best writers—viz. that in the choice and collocation of words in sentences, consistency should be held paramount; that means, that suitable words being chosen to express any idea, the single words employed should be so arranged, and, where necessary, inflected and modified, as to exhibit the unity of the thought in phraseology which precisely and exactly coincides with it, in which the whole structure is harmonious, word with word, and word with thought. Each individual word has its own specific and distinct duty to perform, and, as an etymological unit, has its class-place, and in some cases peculiar changes, such as inflection, &c., wrought in or on itself, and other influences which one word exerts on another. These considerations led grammarians to lay down their regulations for the arrangement of words in sentences (*i.e.* their doctrine of syntax) under two heads: (1) concord, and (2) government.

Concord or agreement requires that all inflected words which are related to one another should have their precise relation properly indicated and maintained by similarity in person, number, gender, case, mood, tense, form, &c. The laws of concord are:—

(1) Nouns and words used instead (*i.e.* as representatives) of nouns signifying the same thing, such as (i.) nouns in apposition, (ii.) pronouns representing nouns, (iii.) adjectives used as nouns, (iv.) phrases, quotations, &c., used as nouns, in the same relation, must agree in case:

> *Newton*, the *astronomer*, was born at *Woolsthrope*, a *hamlet* near Grantham.
> The *crowd* was great, and *it* enjoyed the amusement.
> The *good* alone *are* great [men or women.]
> "The tongue is not steel, but it cuts," is a true proverb [or it may be are true words].

(2) A finite verb (*i.e.* a predicate) must agree with its nominative (*i.e.* its subject) in number and person. This general rule may be put before the mind more particularly and plainly thus:—Objects of thought which may be regarded as singular or plural, must be classed and spoken of in one or other of these two numbers, and as all things may be (grammatically) considered as able to be classified under one or other of the three persons, the words employed to name or represent them must be arranged according to these persons, and thus all nominative nouns (or possible subjects) in regard to the verbs (or predicates) with which they are to be conjoined must fall into one or other of the following forms, and be used in the number and person conforming thereto:—

I. *Singular.*	II. *Plural.*
1. I (or the person speaking).	1. We (or the persons speaking).
2. Thou (or the name of any person addressed).	2. Ye or you (or the names of persons addressed).
3. (i.) He, she, or it; (ii.) a demonstrative, distributive, or adjective pronoun; (iii.) a relative pronoun; (iv.) any singular noun; (v.) any collective noun signifying *unity* of idea; (vi.) two or more singular nouns separated by *or* or *nor*; (vii.) a part of a sentence signifying unity of idea; (viii.) the infinitive mood used as a noun; or (ix.) a quotation or phrase used as a singular noun.	3. (i.) They; (ii.) a demonstrative or adjective; (iii.) a relative pronoun, simple or compound; (iv.) any plural noun; (v.) any collective noun signifying plurality of idea; (vi.) two or more singular nouns conjoined by *and;* (vii.) a part of a sentence signifying plurality of idea; (viii.) two or more infinitives conjoined by *and;* or (ix.) two or more quotations or phrases used as nouns.

1. I am a stranger and a pilgrim upon the earth.
   We are strangers and pilgrims upon the earth.
2. Thou art the man. Ye are the men.
3. (i.) He is famous. She is refined. It is valuable.
   (ii.) This is the general drift of the magna charta.
   These are the actual words of the magna charta.
   (iii.) Who is he? Who are they? Which are the men?
   (iv.) The poet utters thought melodiously.
   The poets utter thought melodiously.
   (v.) The crowd pursues its pleasure eagerly (unity).
   The crowd pursue their pleasure eagerly (plurality).
   (vi.) John or William has done the required work.
   John and William have done the required work.
   (vii.) The general tendency of the people is to assert its rights.
   The actual tendencies of the people are to assert their rights.
   (viii.) To toil or starve is our only choice.
   To toil and starve are but unpleasant prospects.
   (ix.) "Know thyself" is a saying attributed to Thales, Bias, Socrates, and others.
   "Without care" and "without envy" are happy characteristics.

GEOLOGY.—CHAPTER IX.

PRIMARY OR PALÆOZOIC AGE—LAURENTIAN AND CAMBRIAN SYSTEMS.

PLACING before ourselves the ideal section of the outer rind of the surface of the globe given on p. 726—which has been constructed in harmony with the real facts observed by many men of painstaking research and clear-sighted intelligence—we have a *scala geologica*, or geological ladder, exhibiting the steps made in the progress of the ages from the granite period to our own times. Each step of this stony staircase is inscribed with hieroglyphics, from which, when translated, we can learn something regarding the approximate era in which it was constructed, and the condition of the earth during that era. The ripple-written records of primeval seas, the foot-prints left upon their soft sands by the strangely-formed creatures who crawled beside earth's multitudinous waters, the engravings made by glaciers on "the everlasting flint," the exquisitely organized shells of which the clays and limestones have furnished us with moulds, the singular plants which have been so finely embalmed in opal and hornstone, the remains of ancient animals "ensepulchred" in volcanic ashes, petrified in calcite, or carbonized in peat-bogs, the jelly-like medusa which floated in seeming shapelessness on the surface of the summer waves of former epochs, and the mighty mammoth whose huge bulk oppressed the unthawed tundras near Siberian seas in prehistoric times—are all inscriptions left by Nature, for our learning, in the rock-records of the globe. These are the letters out of which, first by surmise and guess, and subsequently by inductive comparison and collocation, geologists have constructed an alphabet of palæontologic lore and a syntax of fossiliferous evidence, by the aid of which the history of the past may be interpreted

and retranscribed from "tables of stone written with the finger of God," and translated into the mother-tongue of modern man.

The term *fossil* is scientifically restricted to the remains or traces of organic life (in plant or animal) found imbedded and preserved in any of the natural formations—whether of hard rock or of superficial deposit—which constitute the earth's crust. The uses to which they may be applied in geological research are twofold: (1) they enable observers to understand the condition of the earth in former eras in regard to the distribution (i.) of vegetable and animal life, (ii.) of land, rivers, lakes, seas, and (iii.) the changes of climate and constitution which the globe has undergone; (2) they furnish (i.) a clue to the arrangement and classification of rocks in a [probable] chronological order, and (ii.) supply a gauge of the life of the globe in olden times, a guide to the investigations of inquirers regarding the disposition of ranks in a series.

It is by making note of these real records of organic development in its progress from lower to higher forms, by marking the gradual succession of the evolutions of Nature's plans, and by taking these as landmarks of the geological revolutions of the past, that the outlines of a chronological consecution of the terrestrial strata superimposed one on another—in an order rigorously determined by means of the faithful fossiliferous inscriptions of flora and fauna—have been reached. By their aid men have learned to read the history of the earth as a planet in space and the home of the human race.

With the first forms of life of which relics are left in the stone-paged records of the earth's crust, the geological historic period begins. The Azoic or Archæan rocks, because they supply no satisfactory means of discriminating them and arranging them in a systematic series, are (at least provisionally) grouped together as uncommunicative in regard to the events by which their phenomena were affected. Granite, gneiss, and other crystalline schistose rocks, require to be accepted as—so far as we can yet ascertain—probably the remains of the primeval fundamental material of an early molten metamorphosed mass, out of which they were formed. From the ruined *débris* of these the overlying layers of the stratified and fossiliferous rocks of the globe have been formed during the successive changes of arrangement, derangement, and rearrangement which seismic and cataclysmic forces and static and stratigraphic influences have effected in the scenery of earth. In the theatre of geologic changes they form the curtain, and all that can be really said of them in the drama of dynamics which geology represents as having been played by heat, pressure and contraction, earthquake and volcano, air and ocean, chemical and mechanical interaction, &c., in the past, is "the curtain is the picture." In the older rocks there may have been a deeper-seated or a more minute and earlier life-system, of which to observers, as yet, the signs are not discernible. It is when the records presented for decipherment come with the evidence of life and traces of organic form that a beginning can be made of the study of the primary types of living forms in the palæozoic age—the age in which the cosmic surface shows signs of inhabitation.

All the great sedimentary formations which in their normal position occupy the lower portion of the stratified material of the telluric shell (*i.e.* are most remote from the present surface) are classified together as those of the primary or the palæozoic (Gr. *palaios*, ancient; and *zoë*, life) period. This great succession of important rocks consists for the most part of sandy or muddy detrital materials, with interpolations or occasionally intervening sections of limestone, stratified mass over mass, and showing everywhere indications of having been formed in shallow water from the *débris* of insular or continental lands. The oldest of the fossil-furnishing rock systems is of vast extent, giving a perpendicular depth of something like 30,000 feet. As lying nearest to the igneous rocks they have undergone a great amount of change in texture and structure, and by metamorphic influence a crystalline character has been superinduced. They may be regarded as composed of granitic or gneiss-like schists, quartzites, and ophiolitic (or serpentinous) limestone. In one of the limestone layers of this lower Laurentian system—as this group of rocks is called, from its being the type-rock of the district of the St. Lawrence River in Canada—there has been discovered, by the aid of the microscope, evidence of the existence of an early *foraminifer* (*i.e.* a minute animalcule consisting of a shell chamber filled with plasmic matter). This *Eozoön Canadense* (*i.e.* Canadian dawn-animal) manifests its reality as a once vital thing by a chambered calcareous shell in which plasma has been replaced by infiltration of dolomite or serpentine, and shows itself in cell-structured coral-like layers among old Laurentian schists. Besides this, from the large percentage of *graphite* occurring in veins, scales, or laminæ in the Ottowa district and at St. John's, it has been inferred that living land-plants have also been plentiful during the Laurentian period. Above the Laurentian rocks—resting unconformably upon, and evidently owing their origin to, them—lie the slate, conglomerates, limestone, and quartz of the Huronian (or Lake Huron) rocks, younger by far than the Laurentians, though in them as yet no fossils have been observed.

One step higher brings us to the less metamorphosed crystalline limestones, grits, schists, and slates of the Cambrian system—so called from their occurring typically in the Cambria of yore, the North Wales of to-day. In these the sedimentary texture is less altered, and the characteristic fossiliferous zones can be more satisfactorily arranged, because the fossils themselves are more distinctly marked, more readily procured, and less altered than in the underlying strata. The Cambrian system extends to a depth of from 20,000 to 25,000 feet, and it has been the battle-ground of a great deal of disputed classification. Even yet no commonly accepted boundary line between the primordial Cambrian strata and the lower Silurian groups is fixed. The Cambrian system is specially important as a treasure store of minerals and metals, being frequently traversed by eruptive masses and veins of materials useful for various purposes. Though by far the larger parts of its reddish-gray, purple, and green slates and conglomerates are unfossiliferous, and it is mostly in the upper bands that fossils are plentifully found, yet that their strata are derived from pre-existent sedimentary rocks is abundantly evident from the fragments of water-worn pebbles of quartzite, greenstone, and jasper they contain. It has been the custom to regard them as forming two groups:

I. Upper	(iv.) Tremadoc (dark-gray), slates, Carnarvonshire, 1000 feet. (iii.) Lingula (bluish, black, and gray), flags, sandstones, and slates, 5000 feet.
II. Lower	(ii.) Menevian (St. David's), gray grits, sandstones, and shales, 600 feet. (i.) Harlech and Longmynd, sandstones, slates, gray flags, and conglomerates, 8000 feet.

Of these, group (i.) has the surface of its strata in many places indented with the ripple-marks of an open sea, with rain-pits and sun-cracks. It was supposed to present no organic remains, but besides the trail of worms over soft shore-deposits, sixteen species of tiny trilobites (*i.e.* three-lobed crustaceans), five brachiopods (arm-footed bivalved molluscs), four annelids (worms), two pteropods (molluscs having wing-like fins), and one sponge have been found. Group (ii.) is closely allied in character and fossil remains. Among these trilobites predominate, and some of them reached a great size. Of these, thirty species have been found, six brachiopods, five pteropods, and four sponges. Some worm-tracks have been traced, and not only the earliest cystidean but the first of the entomostracans. Group (iii.) abounds (as its name implies) in lingula, a bivalve with a thin horny or calcareous shell, and a long, hollow, fleshy tube, called a *peduncule*, between the apices, by means of which it was enabled to attach itself to external objects. These lingula flags are generally divided into three bands or zones, each of which is distinguished by the fossils it contains. The lower exhibits thirty-seven species, of which nine are peculiar to it; the middle, five, of which two are peculiar; and the upper, forty, of which nine take also a place among the Carnarvonshire group; but in all three, these oblong, triangular, smooth, flattish, palliobranchiate (*pallium*, a mantle, and *branchiæ*, gills) bivalves maintain their ascendency. Group (iv.) presents in its dark-gray slates a varied and

abundant fauna, among which appear the earliest *crinoids*, star-disced, lily-shaped sea-animals fixed on a flexible stalk, sometimes called stone-lillies; *asteriadæ* (star-fishes), whose fleshy, sucker-tipped ambulacra, placed in rows and passing through orifices in the disc, enabled them to move and seek their prey; *lamellibranchs; acephalous molluscs*, whose gills took the form of semicircular layers; and *cephalopods*, the most highly organized of the invertebrate creatures, the progenitor of that fairy-like shell-ship sailor the *nautilus*.

It has been proposed to subdivide this group into two zones, lower and upper; but, at present, it is at the geological and palæontological "break," which occurs at the top of the upper Tremadoc slate-strata, that the line of division is placed between the Cambrian and the Silurian rocks. A careful study of our Geological Map of the British Isles will speedily teach more about the distribution of these old sedimentary formations than could be set forth in a lengthily detailed series of stratigraphical descriptions of the reddish-brown picturesque sandstone and conglomerates which in the north-west of Scotland represent these rocks, or the red, purple, and green, considerably metamorphosed, masses of shales, slates, grit, &c., which in the south-east of Ireland, to a depth of 14,000 feet, seem to be kindred to the lower Cambrian combinations. Similar strata are found in northern Germany, Scandinavia, and Russia, in northern Europe, and in France, Portugal, Spain, Bohemia, and Sardinia in the central and southern districts. American geologists recognize this formation in many parts of the United States and Canada. They divide it into two groups: (1) Acadian, with a thickness of 2000 feet, in and around Nova Scotia; and (2) Potsdam or Georgian, with a thickness of 5600 feet. Continental geologists sometimes refer to the most ancient fossiliferous rocks as the primordial zone, and it is probable that great changes may yet be made in the nomenclature, subdivisions, and classifications of these stratified structures. The boundary that may be fixed upon, and the changes in all these matters it would be hazardous to guess.

ALGEBRA.—CHAPTER VIII.

I. OF SIMPLE EQUATIONS CONTAINING ONLY ONE UNKNOWN QUANTITY.

THE relation of algebraical expressions to one another are, as we have already said, those of (1) identity (*e.g.* $x=9-5=4$), and (2) condition. Every equation of condition is, in reality, a process of reasoning, in which, setting out with the unquestioning acceptance of the truth of the equation given us, we proceed step by step, making advances more or less gradual, by the use of the common rules of arithmetic and algebra, towards a solution of the question, that is, the discovery of the number for which the algebraic letter-sign must be held as standing, so that the equation, under the condition stated, may be true. The quantity, the value of which is to be determined by the equation, is in general represented by one of the last letters of the alphabet, and all others are given either in arithmetical figures or some of the earlier alphabetical letters. This is a distinction usually observed in giving questions to beginners; but it is not at all a necessary one. It is far better to learn early to regard any letter-sign as standing for and representing any quantity, known or unknown, which may be determined upon, in accordance with the (stated) conditions of the problem. Here, for instance, is a simple equation of condition; let us first examine it carefully, and then see if we can gather up the principles which are found latent in it.

Four merchants bought a ship for £5214. Of this sum, B paid twice as much as A, C as much as both A and B, and D as much as B and C. What were their respective shares?

Let A's share be represented by x; then B paid $2x$, C $3x$, and D $5x$—that is, in all, $x+2x+3x+5x=11x$; now $11x=$ £5214, *i.e.* $x=$ £474, A's share; $2x=$ £948, B's; $3x=$ £1422, C's; and $5x=$ £2370, D's. By adding these sums together it will be seen that their total amounts to £5214, and this shows that the answers are correct.

This is a very simple and easy question—as indeed all examples must be which are intended to illustrate any new sort of operation in thought or practice. The enunciation of the conditions of the equation here almost immediately insures the correct solution of the question put. We may try another simple variety of the algebra of equations.

Two numbers are such that their sum amounts to 47, while their difference is 23. What are these numbers?

Let x represent the less of the two numbers; then $x+23$ will represent the greater; and both together, *i.e.* $x+x+23$, must by the condition of the question equal 47. This supplies us with the next process, $2x=47-23$, *i.e.* $2x=24$, *i.e.* $x=12$, which is the lower number of which x was the representative. To gain the higher number we have $x+23=12+23$ (*i.e.* the lower number and the difference between the two added together), hence $x+23=35$ (*i.e.* the higher number). The two numbers are therefore 12 and 35, which being added give 47.

The process here followed is that we denote the unknown quantity by x, represent the operations to be performed by their usual signs, and in accordance with the conditions of the equation work them out. Sometimes, however, we require to use a little thought to get at the best means of putting the equation expressed in a workable form. If, for instance, a question like the following be given:—

A gentleman being asked for a subscription said he had in his purse only shillings and half-crowns—of which coins, taken together, there were 24, equal in value to £2 14*s.*, and he would give the person soliciting him either the shillings or the half-crowns, at his option. Which would it be best to choose? It is here, of course, more desirable to get *value* than *number*, and hence we require to select a unit of value. If we take *pence*, we can say $x=$ the *number* of shillings, and $12-x=$ the *number* of half-crowns. Then the *value* of the x shillings is $12x$ pence, and the *value* of the $24-x$ half-crowns is $720-30x$ pence. Thus we have $720-30x+12x$, *i.e.* $720-18x$. Therefore these together are equal to £2 14*s.*, *i.e.* 648. The equation stands thus then, $720-18x=648$; transposing these elements we get $18x=648-720$, *i.e.* $18x=72$, *i.e.* $x=4$, the number of shillings. Next we have 24 (the whole number of coins) $-4=20$, the number of half-crowns. Twenty half-crowns equal £2 10*s.*, to which add 4*s.*, giving the total, £2 14*s.*

But we might get this answer more simply by choosing a different unit of value, such as *sixpence*. In this case we should have x representing the number of shillings, giving the value $2x$; the $24-x$ representing half-crowns, giving $120-5x+2x=108$. This yields $120-3x=108$, and that $-3x=108-120$, *i.e.* $-3x=12$, *i.e.* $x=4$, the number of shillings as before. The subtraction of 4 from 24 leaves 20 half-crown coins. Thus we see that the chooser of the shillings would only get a subscription of four shillings, while the chooser of half-crowns would get fifty shillings, *i.e.* £2 10*s.*

Clear-headed skill in stating equations in the symbolical language of algebra cannot be taught by rules, for no rules can be sufficiently minute to suit every case. Most books on elementary algebra afford numerous and useful exercises of ingenuity in making out curious questions, which, though they may never occur in real life, are valuable for stirring the the mind and giving it the opportunity of fixing the principles of equations in the mind. These we shall now proceed to explain.

The unknown quantity in equations coming under this head, is necessarily of the *first* degree. It can be combined with the known quantities only by addition, subtraction, multiplication, and division. Thus the principles already explained and exemplified in the preceding chapters are amply sufficient for their solution. But before translating these principles into a general rule, we shall briefly exhibit them in the symbols which constitute algebraical language. For that purpose, let X and P be the members of an equation in its unreduced form—*e.g.* let X (whatever it be) $=$ P.

Then the equation still exists, as we have shown (p. 725) in our illustrations of the axioms, when X and P are both of them either increased or diminished by the same quantity, and consequently by any two quantities which are reducible to identity with each other. Thus, the above equation $(X=P)$ being true, the following are also true:

$$X+A=P+A \qquad X-A=P-A$$

And if A=B+C then will these equations also be true:—

$$X+A=P+B+C \qquad X-A=P-B-C$$
$$X+C=P+A-B \qquad X-C=P-A+B$$

It is in consequence of the truth of this proposition that quantities may be *transposed* from one side of an equation to the other, by merely changing their signs from + to −, or from − to +. Thus, if the primitive equation be $X-A=R$, by adding A to both members we get

$$X-A+A=R+A \quad \text{or} \quad X=R+A$$

Similarly, if $X=R+A$, by subtracting A from both sides we get

$$X-A=R+A-A \quad \text{or} \quad X-A=R$$

From these several plain examples it follows that every equation admits of such a modification of its form that all its significant terms may be brought together so that *they* form one of its members and zero the other: for if

$X=P$, by subtracting P we get $X-P=0$.

Again, the equation will continue to exist though X and P are both of them either multiplied or divided by the same quantity or by quantities which are identical in value with each other, thus:

$$\text{If } X=P, \text{ then } AX=AP, \text{ and } \frac{X}{A}=\frac{P}{A}.$$

And if $A=B+C$, the following equations are likewise true,

$$AX=BP+CP \qquad \frac{X}{A}=\frac{P}{B+C}.$$

It is in consequence of this fact that we are able to clear an equation of fractional terms, as shown in p. 729, and so to free the unknown quantity of its coefficient, when we have succeeded in bringing the equation under the form $ax=b$; where b is the product of x multiplied by a, and therefore $x=\frac{a}{b}$.

These examples, and the principles which they imply, enable us to derive these rules for the solution of simple equations containing only one unknown quantity:

1° *Clear the equation of fractions.*

2° *Transpose the terms involving the unknown quantity to one side, and those which do not involve it to the other.*

3° *Collect the separate terms in that member of the equation which involves the unknown quantity into one term.*

4° *Divide both members of the equation by the coefficient of the unknown quantity.* This gives the solution required.

The following are preliminary instances of the application of this rule to numerical equations, reference being made to the rule by means of the numbers 1°, 2°, 3°, 4°.

Example 1. Given $x+\frac{3x-5}{2}=12-\frac{2x-4}{3}$.

By 1° $6x+3(3x-5)=72-2(2x-4)$.
By 2° $6x+9x+4x=72+8+15$.
By 3° $19x=95$.
By 4° $x=\frac{95}{19}=5$.

Verification. If $x=5$,

$$x+\frac{3x-5}{2}=5+\frac{15-5}{2}=10 \quad 12-\frac{2x-4}{2}=12\frac{10-4}{3}=10.$$

II. EXERCISES IN, AND HELP TO THE SOLUTION OF, SIMPLE EQUATIONS.

It is obvious that equations must undergo some alteration of their form of expression, so that they may be prepared for yielding true solutions as to their values. The changes which are possible have been made the subject of rules for guidance in operations, and these—as given above—are said to govern the solution of equations.

Exercises. (1) $x-5=7$. This yields as the value of x this result: $x-5=7$; therefore $x=5+7$, *i.e.* 12.
(2) $x-17=24$; therefore $x=24+17$, *i.e.* 41.
(3) $z-72=-38$, hence $z=72-38$, *i.e.* 34.
(4) $5x-3=2x+5$; therefore $3x=8$.
(5) $12-3x=6-10x$; therefore $7x=-6$.
(6) $6x-4a=10c-4x$; therefore $10x=4a+10c$.
(7) $\frac{x}{5}=8=8=40$. (8) $8x\div13=x=208$.

It is often advantageous, before commencing a solution, to simplify an equation by performing the more obvious operations indicated among the terms. The following is an instance:—

Example 2. Given $5x+\frac{7x-1}{2}-\frac{x-1}{4}=\frac{5x+11}{6}+\frac{11x+15}{2}$

$$\text{Here } 5x+\frac{7x-1}{2}-\frac{x-1}{4}=\frac{20x+(14x-2)-(x-1)}{4}$$
$$=\frac{33x-1}{4}$$

$$\text{And } \frac{5x+11}{6}+\frac{11x+15}{2}=\frac{(5x+11)+(33x+45)}{6}=\frac{19x+28}{3}$$

$$\text{Therefore } \frac{33x-1}{4}=\frac{19x+28}{3}$$

By 1° $99x-3=76x+112$.
By 2° $99x-76x=112+3$.
By 3° $23x=115$ ∴ (by 4°) $x=5$.

Verification. If $x=5$; $\frac{33x-1}{4}=41 \qquad \frac{19x+28}{3}=41.$

If the same quantity be found on both sides of an equation and have the same sign, it is quite obvious that it may be omitted.

$9x-30=8x-10$ $\qquad x=20$. *Ans.*
$x-a^2-ab=a^2-bc$ $\qquad x=ab-bc$. *Ans.*
$\frac{x}{2}-6=6-\frac{x}{4}$ $\qquad x=16$. *Ans.*

The following are instances, the processes of which the student should most carefully review until thoroughly familiar with them.

Exercise 1. From $\frac{x}{2}-2=5-\frac{x}{5}$, find x? $x=10$. *Ans.*
" 2. " $\frac{x+3}{4}-\frac{x-3}{5}=\frac{x-5}{2}-2$? $x=13$. "
" 3. " $\frac{x}{2}\ \frac{x}{3}\ \frac{x}{4}=13$? $x=12$. "

Example 3. Given $3x+5=20-2x=$(by transposition.)
$3x+2x=20-5=$(")
$5x=15$, or $x=15\div5=3$. *Ans.*

Example 4. Given $\frac{4x+3}{9}+\frac{7x-29}{5x-12}=\frac{8x+19}{18}$

×(18) $\qquad 8x+6+\frac{18(7x-29)}{5x-12}=8x+19$

−(8x+6) $\qquad \frac{126x-522}{5x-12}=13$

×(5x−12) $\qquad 126x-522=65x-156$
By 2° and 3° $\qquad 61x=366$
∴ By 4° $\qquad x=6$

Verification. If $x=6$; $\frac{8x+19}{18}=\frac{48+19}{18}=\frac{67}{18}$

$$\frac{4x+3}{9}+\frac{7x-29}{5x-12}=\frac{27}{9}+\frac{13}{18}=\frac{67}{18}$$

The rules for the solution of literal equations are precisely the same as when the equation is given in numerical terms. We subjoin an example of a general nature, the letters a, b, c, d, and so on, being used to denote known quantities, *i.e.* quantities of which we are supposed to know the numerical values.

Example. Let $\qquad ax+b=cx+d$
By 2° $\qquad ax-cx=d-b$
By 3° $\qquad (a-c)x=d-b$
By 4° $\qquad x=\frac{d-b}{a-c}$

Verification. $ax+b=a\left(\frac{d-b}{a-c}\right)+b=\frac{ad-ab+ab-bc}{a-c}$

$$=\frac{ad-bc}{a-c}$$

$$cx+d=c\left(\frac{d-b}{a-c}\right)+d=\frac{cd-bc+ad-cd}{a-c}=\frac{ad-bc}{a-c}$$

The following easy exercises ought now to be gone over, seeing to every step in the process most carefully:—

(1) A person became bankrupt—the share of the loss borne by four creditors amounting to £309. Of this loss, £3 less fell upon B than upon A, and twice as much as both on C. What were their respective shares?

A's loss, x; B's, $x-3$; C's, $4x-6$. Total [?]$=309$; hence $6x=309+9$, *i.e.* $6x=318=x=$[?]. Therefore $x=$ £53, *i.e.* A's share; B's, £50; and C's, £206. Total, £309.

(2) A undertook to pay B a bill of £700 in equal quantities of sovereigns, half-sovereigns, and crowns. How many of each did he require?

The number required is x. Taking the number of shillings included in the value of each coin, we have $20x+10x+5x$ $=$£$700\times 20/$, *i.e.* [?] shillings. This gives $35x=$[?]$=x=400$ of each—viz. 400 sovereigns, *i.e.* £400; 400 half-sovereigns, *i.e.* £200; and 400 crowns, *i.e.* £100. Total, £700.

(3) Divide the number 100 into two parts, of which the first, when multiplied by 12, shall exceed the second, when multiplied by 11, by 4.

Of course x represents the 1st number.
$100-x$ " 2nd "

Arranging for the fulfilment of the conditions we transform those signs thus:—

$$\left.\begin{array}{l}12x-11,\ i.e.\ 100-x=4\\ 12x-1100+11x\quad =4\end{array}\right\}\text{ these give }\left\{\begin{array}{l}[?]\ x=1104\\ i.e.\ x=\ \ 48\end{array}\right.$$

$x=48$, the 1st No.; $x+4=52$, the 2nd No. Proof, 48×12 $=576:52\times 11=572$.

An uncle in Australia remitted a gift of £560 to a nephew and niece, to be divided so that for each half-crown the niece got the nephew was to get a shilling. What were their respective shares?

$x=$the niece's share in pounds, and let $8x$ be the half-crowns she was to have. The $8x$ would represent the shillings the nephew should have, and the equation would stand $x+\frac{8x}{20}=$ £560, therefore $20x+8x=$[?] shillings, and $28x$ $=$[?] shillings, the $x=$ £400 niece's share, £160 nephew's.

This same question may be worked more simply by saying, $x=$nephew's share; $2\frac{1}{2}x=$niece's share; therefore $3\frac{1}{2}x=$ £560, and $7x=$ £1120. Then $x=$ £160, and £$160\times 2\frac{1}{2}=$ £400—the respective answers.

ASTRONOMY.—CHAPTER X.

COMETS — THEIR MOVEMENTS — NUMBER — SHORT-PERIOD COMETS — HALLEY'S COMET — ENCKE'S COMET — BIELA'S COMET—LONG-PERIOD COMETS—RECENT COMETS—AEROLITES — FIREBALLS AND METEORS — SHOOTING STARS—RADIANT POINT — THEORY OF SHOOTING STARS—THE ZODIACAL LIGHT.

COMETS are among the most interesting objects which the astronomer has to consider and investigate. Appearing suddenly in the heavens, sometimes as a star, and often with tails of immense size and brilliancy, they attract the attention of every one. The comet usually consists of three parts: the *nucleus*, composed of nebulous matter more condensed in its light than the rest, is sometimes circular, sometimes oval; the *coma*, a cloud-like mass around the nucleus, which gradually becomes less regular, and a *tail* begins to form, which becomes fainter as it recedes from the body of the comet. This tail frequently increases in length so as to sometimes spread across a large portion of the heavens; sometimes there are more tails than one. The form of the head, and its apparent and real dimensions, and the form and dimensions of the tail, are extremely variable. Some comets are deprived of both tail and nucleus (fig. 1, Plate IX.) a simple nebulosity, differing only from the nebulæ proper in so far that while these latter retain a fixed position in the heavens, the cometary nebulosity moves rapidly across the sky.

Comets form part of our solar system, and, like the planets, they revolve round the sun, traversing with very variable velocities extremely elongated orbits. The form of this orbit furnishes the first of their specific characters. The orbit of the planets is nearly circular, but most of the comets revolve round the sun either in extremely elongated ellipses or in curves which appear infinite. Comets are therefore observable only in a very limited portion of their paths, when they approach nearest to the sun and earth. Another distinguishing characteristic is that the inclinations of their orbits to the ecliptic, instead of being contained, like the planetary orbits, within very small limits, take every possible value; hence they traverse the heavens in every direction. Again, the direction of their movement is sometimes from west to east, and sometimes in the contrary direction, that is, sometimes *direct* and sometimes *retrograde*.

The planets always move in the same direction, from west to east—from right to left, that is, to an observer placed on the northern side of the plane of the ecliptic. Comets approach the sun in a curvilinear path, which frequently differs but little from a right line. They generally cross that part of the heavens in which the sun is situated, so near the latter body as to be lost in its rays; but they emerge again on the other side, frequently with increased brilliancy and increased length of tail. In magnitude and brightness comets greatly vary; some are so bright as to be visible in the day time, others again are quite invisible, except with powerful telescopes. The appearances of the same comet at different periods of its return are so varying that it is difficult to identify it unless its elements have been calculated and compared. Often the same comet may successively return to our system, sometimes with a tail and sometimes without a tail, according to its position with respect to the earth and the sun, and it is also believed that comets in general, from some unknown cause, decrease in splendour in each successive revolution. It is estimated that the number of these bodies which traverse the solar system within its known limits—that is to say, within the orbit of Neptune—is over 17,500,000. Up to the present time the orbits of more than 300 comets have been calculated. The trains of some great comets have been seen to scintillate in a manner somewhat similar to the Aurora Borealis—the vibrations commencing at the head, and appearing to traverse the whole length of the comet in a few seconds. This appearance is, however, evidently due to the effects of our own atmosphere, as were it due to the matter composing the comet itself several minutes must elapse before the coruscations from the extremity of the tail could reach us, being so much further off than the end near the nucleus. The pulsations are, however, almost instantaneous. Most of the comets observed visit the celestial regions occupied by our world for the first time, or if they have already appeared before, their visit has happened at periods so remote from ours that no record has been handed down. Before the period of a comet's return can be predicted, the elements of its motion must be ascertained. A certain number of comets move in closed orbits, that is, in ellipses, so that comets of short period are distinguished from those whose revolutions occupy centuries. In the case of comets of short period, their elements are now known to a precision which enables their return to be predicted for any given day and hour, with the various positions they will occupy in the heavens.

The first comet that was thus calculated bears the name of the English astronomer of the seventeenth century, Halley, who identified the comet of 1682 with those of 1531 and 1607, and predicted its return at the end of 1758 or the beginning of 1759. The event justified the prediction. The perturbations of the two large planets Jupiter and Saturn, in the vicinity of which the comet was expected to pass, were calculated to retard its appearance by 618 days; 100 due to the action of Saturn, and 518 to that of Jupiter. The return of the comet was therefore predicted to occur in the middle of April, 1759; it actually returned to perihelion on the 13th

SHORT PERIOD COMETS — LONG PERIOD COMETS

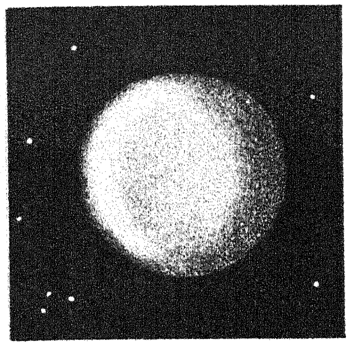


Fig 1. Comet without tail or nucleus.

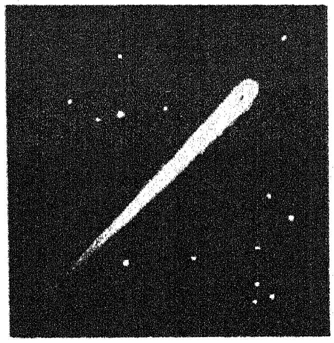


Fig 2. Halley's Comet, 1835.

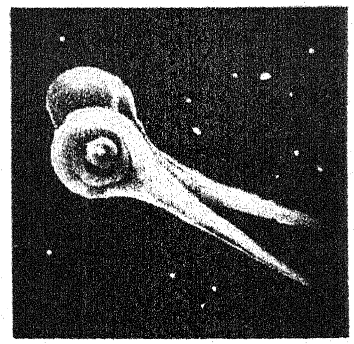


Fig 3 Subdivision of Biela's Comet.

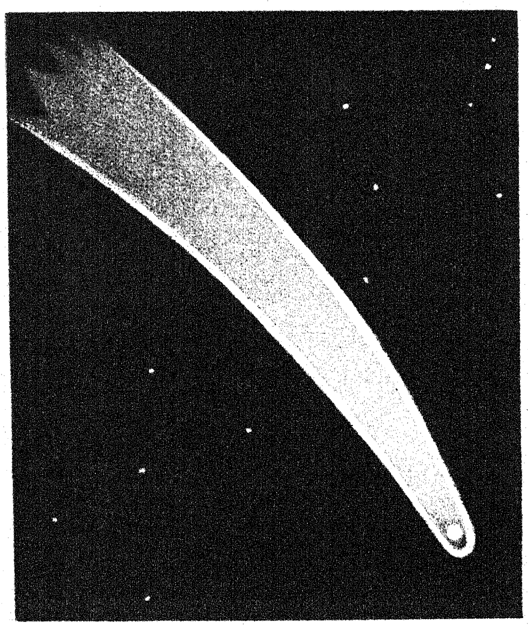


Fig 4. The Great Comet of 1811.

Fig. 5. Donati's Comet passing Arcturus, Oct. 5. 1858.

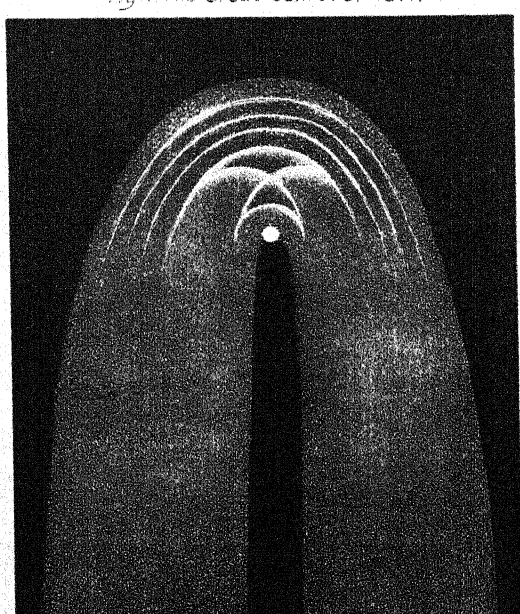


Fig 7. Coggias Comet. July. 1874.

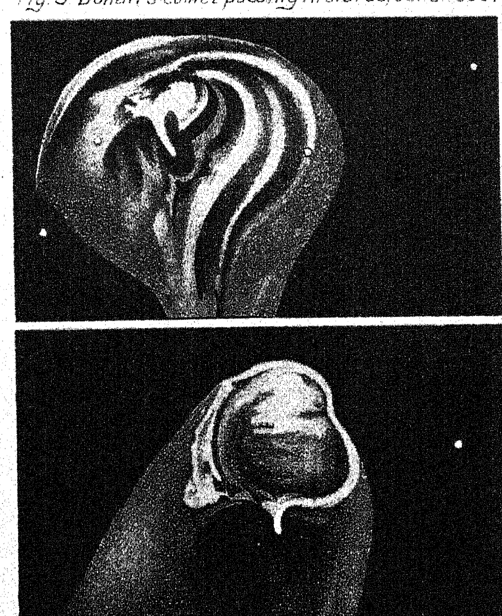


Fig. 6. Aspect of head of Comet, 1862, 23 & 24 Aug.

of March. In 1835 Halley's comet reappeared, with only three days' difference between calculation and observation (fig. 2 in Plate). This comet requires a period of more than seventy-six years (27,866 days) to traverse its elliptical orbit. Encke's, the second which was calculated, accomplishes its revolution round the sun in the shortest space of time, which in the mean is 1205 days, or a little less than $3\frac{1}{3}$ years. It moves from west to east in an elliptical orbit, of which the perihelion and aphelion distances are respectively 32,000,000 and 387,000,000 miles. Since 1818, the date of its discovery, all its returns have been regularly observed, but it is found that the period of its revolution is constantly diminishing, so that if this progressive diminution always follows the same rate, the time when the comet, continually describing a spiral, will be plunged into the incandescent mass of the sun can be calculated. There are several other comets of short period whose orbits are calculated; it is, however, only necessary to notice Biela's comet. This remarkable comet was discovered in 1826, and its first reappearance occurred in the autumn of 1832, causing great excitement, as it was calculated that in its passage round the sun it must meet the earth, or at least approach it within 20,000 miles. More accurate calculations, however, determined that the comet would cross the earth's orbit one month before our globe would reach the point of passage. This comet has, however, been subjected to a strange transformation, for in 1846 it appeared under the form of two comets (fig. 3) of unequal size, which gradually separated more and more. In 1852 the two comets reappeared travelling together, but the distance between the two nuclei, which was 150,000 miles in 1846, then amounted to 1,240,000 miles. In May, 1859, it passed undetected, owing to its close proximity to the sun. In January, 1866, it was calculated that the comet would have been seen under very favourable circumstances, and careful search was made for it at the several European observatories, but without success, and the existence of the comet seems now so open to uncertainty that all hopes of seeing it again are abandoned, as it was not seen either in 1872 or in 1879.

It was the astronomer Kepler who remarked that comets are scattered throughout the heavens with as much profusion as fishes in the ocean. And yet numbers of these comets take thousands of years to accomplish their circuit. The great comet of 1680 has a period of about 8814 years; and the period of the comet of July, 1844, has been calculated at not less than 100,000 years, so that it will not be again visible before the year 101,844. The velocity of comets diminishes, like that of the planets, as their distance from the sun increases, and at their greatest distance it is extremely small (the comet of 1680 scarcely travelling, at its aphelion, more than 9 feet a second), while their velocity at perihelion is enormous.

The great comet of 1811 is perhaps one of the most remarkable on record (fig. 4) and the most brilliant ever seen, being visible in full day. The nucleus had a diameter of about 428 miles, and was of a ruddy hue, the surrounding nebulosity having a bluish-green tinge, and measuring 112,000 miles in diameter. Its period is 3065 years. The tail of this comet attained a length of 112,000,000 miles, and was nearly of uniform breadth. The most remarkable and brilliant of recent comets is that of Donati, 1858 (fig. 5). Its period is about 2000 years. The comet of 1862 is also remarkable on account of the formation of the tail (fig. 6), and the emission of luminous jets. Coggia's comet, discovered in 1870, is remarkable from the enormous size of the nucleus, estimated by Hind to be 4000 miles in diameter (fig. 7). This comet approached to within 26,000,000 miles of the earth, and the tail was upwards of 25,000,000 miles in length. Its period is estimated at about 10,000 years. At the present day astronomers have no hesitation in assuming that the mass of comets is such a small fraction of the mass of the earth that any interference with our earth by a comet would be imperceptible; indeed there is good reason to suppose that the earth actually passed through the tail of the comet of 1861. In 1770 a comet was seen to traverse the system of Jupiter without inducing the smallest perturbation in the movement of the satellites, while that of the comet was so disturbed that its entire orbit was changed. The direction of the movement of the short-period comets is the same as that of the movements of the planets, from west to east. Among the periodical comets, that of Halley's is the only exception. At present the phenomena connected with comets remain very obscure; even the question of the light which renders them visible in space is undetermined. Do they shine by their own light? or is their light borrowed from the sun? or is it partly from both these sources? The spectroscope has to a certain extent revealed the nature of the light of some of the comets, but the modifications to which these strange bodies are subjected, the extraordinary rapidity with which the tail is formed, developed, diminished, and again absorbed, remain at present a problem for future solution. Perhaps the most intelligible recent theory of their nature is that suggested by Proctor, that they consist of volcanic matter ejected from the giant planets, or the sun himself, with such velocity as to overcome the power of gravity, which tends to cause their falling back on their place of origin, and to compel them to pass away into space in orbits of their own, although this hypothesis still leaves much to be explained.

Fireballs or meteors are those brilliant points of light which appear suddenly detached from the heavens; their number is very variable, according to the time of the year. During ordinary nights the mean number of shooting stars observed in an interval of an hour is from four to five. This interesting phenomenon comprises three distinct types: what are termed aërolites or meteoric stones, fireballs, and shooting stars. Meteoric stones, the rarest form of shooting star, which have fallen, have been found in different parts of the world; these masses, undefiled until the time of their fall by living contact, enable us to obtain precise notions of the composition of the most distant celestial bodies. Their structure is nearly always the same. Of the sixty-seven elementary substances known, twenty-four have been found in meteoric stones, namely—oxygen, hydrogen, chlorine, sulphur, phosphorus, carbon, silicon, iron, nickel, chromium, cobalt, manganese, copper, tin, antimony, aluminium, magnesium, calcium, potassium, sodium, lithium, titanium, arsenic, and vanadium. Latterly the presence of nitrogen has been detected. The produce of a meteoric shower is divided into meteoric iron—an alloy not yet found to exist among terrestrial minerals, composed of iron, with from 15 to 18 per cent. of nickel, and small quantities of cobalt, manganese, tin, copper, and carbon; and meteoric stone, composed of minerals found abundantly in lavas and trap-rocks, and consequently of volcanic origin. The circumstances attending the fall of aërolites are very variable. Frequently the fall is accompanied by a loud detonation, and from the manner in which they penetrate the earth, often to a considerable depth, they appear to fall in a direction very oblique to the plane of the horizon. Their initial velocity is also very great, bearing a finite proportion to the velocities which characterize the planetary members of the solar system. This velocity is soon lost on entering the earth's atmosphere, and by the time they reach the ground they possess little more motion than what appertains to them as bodies falling under the influence of gravitation. From observations made by Arago of 206 recorded falls of aërolites, it appears that the monthly average from December to June is less than that from July to November, and that the months of March, May, July, and November exhibit maximum numbers. From this it appears that the earth, in its orbit round the sun, would seem to encounter a great number of aërolites in passing from aphelion to perihelion, or between July and January. It is stated to be a general rule that the area over which a shower of stones falls is oval, measuring from 6 to 10 miles in length, by 2 or 3 in breadth, and that the largest stones are found at one extremity of the oval. When found entire the stones are covered with a glaze of a thin dark-coloured crust formed from the molten substance of their surface. The largest fall of meteoric stones on record occurred on 26th April, 1803, in Normandy. It appears that a very brilliant meteor was observed traversing the heavens with great velocity, and some moments afterwards a violent explosion took place. The noise appeared to emanate from a small cloud at a great elevation; the detonation was followed by the fall of an immense number of mineral fragments, nearly 3000 being afterwards collected,

the largest weighing $8\frac{3}{4}$ lbs. A mass of meteoric iron weighing 15 cwts. was found in 1828 at Caille, in France, and is now in the mineralogical department of the Natural History Museum of Paris. Fireballs or meteors appear to hold an intermediate position between aërolites and shooting stars. They appear suddenly, and after exhibiting a brilliant flame of light for a few seconds, as suddenly disappear. Their form is usually circular or oval, and of perceptible magnitude. Frequently they leave behind a train of sparks with an illuminating power nearly that of the moon. Occasionally they explode into fragments, which continue their course or are precipitated to the earth in the form of aërolites. The average velocity of meteors appears to be about 34·4 miles per second, while the earth's orbital motion is 18·2 miles per second. The velocity of many of these fireballs is greater than that of any of the planets, and the general direction of their motion is contrary to that of the earth. The height of meteors from the earth's surface is often very considerable, varying between 7 and 310 miles. At two periods of the year, about the 10th of August and the 11th of November, the phenomena of shooting stars are at the maximum, and the number of shooting stars observed in one hour is often more than ten times that seen on ordinary nights. During the remarkable display which occurred 12th–13th November, 1833, it was estimated that during each hour of the seven hours the phenomena lasted, upwards of 240,000 shooting stars traversed the heavens. Most frequently the paths described by shooting stars have the appearance of straight lines. Their brilliancy is also very variable; some have surpassed in apparent size the most brilliant fixed stars; the colour likewise varies. In observing any number of shooting stars, about two-thirds are white, the remainder being yellow, reddish-yellow, and green. A circumstance of great importance, as throwing light on the origin and cosmical nature of these meteoric showers, is, that it is observed that the direction of the trajectories is such that the meteors appear to be emitted from the same part of the heavens, called the *radiant point*, because they radiate from it in all directions. The star μ in the constellation of the Lion, is the radiant point of the November showers, while γ, in Perseus, is the radiant point of the stars observed in the month of August. Upwards of fifty-six radiant points are shown to exist in the different periods of the year. These facts seem to point out that shooting stars are external to our atmosphere, and that their movements are independent of the rotation of the earth. The theory now generally accepted is, that the appearance of shooting stars is caused by the earth's passage through rings composed of myriads of these minute bodies circulating, like the larger planets, round the sun, and the parallel movements of which, as seen from the earth, seem to radiate towards that part of the heavens approached by our earth. This theory supposes at least two rings, one through which the earth passes in August, and another in November, and that when the earth in its orbit breaks through one of the rings or passes near it, its attraction overpowers that of the sun, and causes them to impinge on our atmosphere, when their motion, being at once arrested, is converted into heat and light, and they become visible either as shooting stars or fireballs, according to their size.

A curious, and as yet not very fully understood, portion of the solar system is called *the zodiacal light*, a peculiar nebulous light of a conical or somewhat triangular form, which may frequently be noticed in the evening soon after sunset, about February or March, and in the morning before sunrise about September. It extends upwards from the western horizon in the spring, and from the eastern horizon in the autumn (fig. 6, Plate IV.) Generally its axis is in a line with the ecliptic, or in the plane of the sun's equator. As the days lengthen the zodiacal light becomes invisible. The brightness of the light is comparable with that of the Milky Way, but it is more uniform, generally less white, and inclining towards a yellowish-red colour in the parts nearest the horizon. At present no satisfactory explanation has been given of this phenomenon, but it is very generally considered to be a kind of envelope surrounding the sun, and extending nearly, if not quite, as far as the earth's orbit, possibly in the form of a flattened nebulous ring. The direction of the axis of the cone, or of the pyramid prolonged below the horizon, always passes through the sun. The length of the longer axis of the ring is variable, according to the time of observation. Whatever may be the true nature of the zodiacal light, observations prove that the substance of which it is composed lies in a region which sometimes extends beyond the earth's orbit, and sometimes lies within it. Recent observations by Birt tend to show that the greater portion of the zodiacal light always lies to the north of the ecliptic, and that by comparing the shape of the cone of light month by month from February to April, it becomes progressively more and more blunt, so much so as almost to lead to the conclusion that the phenomenon is viewed differently as the earth advances in her orbit from the point at which it was viewed in the winter months.

PENMANSHIP.—CHAPTER IX.

DIFFICULT COMBINATIONS IN WRITING CLASSIFIED AND EXPLAINED.

It is a very prevalent idea that "writing is an almost purely mechanical art," which requires perhaps attention, carefulness, perseverance, a good eye, and a trained hand, but needs little, if anything, else to attain elegance and swiftness in its practical use. But penmanship is really not quite so much a mere matter of imitation as many people imagine; and probably it results more from this mistaken notion than from anything else, that writing is so often taught in an incidental and perfunctory way, as if it demanded no intellectual application, and could be attained only by long-continued dull drill in copying and recopying lithographic specimens of handwriting—ever aiming at, but never attaining to the art of emulating those marvellous complexities of straight and curved lines, which are the despair alike of the ingenious and the ingenuous practitioners of penmanship for their immaculate faultlessness and their unexplained permutations. It has been made clear enough in the foregoing chapters that penmanship is not "the most dull and dreary, monotonous and unintellectual, merely manual and imitative occupation to which a human being can by possibility be set." The method of mechanical and repetitive imitation—especially when combined with the use of engraved copy-lines (as they are called)—is the chief means employed, but not the best that can be pursued. Taught as a specific art, and not—as perhaps, indeed, it ought to be—a particular application of drawing, it requires the inculcation of clear and correct elementary notions of a small number of selected forms; distinct ideas of the relations into which they (may, can, and do) enter, one with another, to produce, as their result, complex forms of a higher order, having an intellectual significance, and capable of being combined together in an infinite multitude of ways in the course of which they are variously modified; and plain methods of knowing how to use them all readily in practice. Instead of presenting a full, correct, systematic series of the most necessary, usual, and difficult forms and combinations to the person engaged in learning penmanship, those forms and combinations which afford the finest opportunities for flourishes, and of placing the pleasantest looking productions of the pen at the head of a copy, are most frequently adopted—so that, in point of fact, during a lengthy curriculum there are a great many very common concurrences of letters which never come within the range of the specimens prepared for their instruction. We intend in this chapter to take a new departure in this matter, and to select and classify for our students some of the more difficult and less familiar combinations of written characters, which are in most cases carefully excluded from engraved headlines, and are, therefore, such as they supply no patterns for nor instructions about. Fortunately it will not require much trouble, on the part of those who have seized the meaning of the descriptive directions our previous chapters have contained, to follow the classification we supply, and to profit by practice from the hints we shall offer upon them.

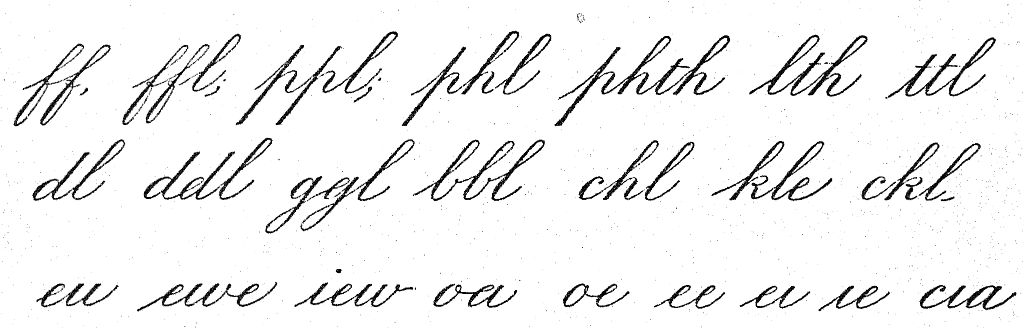
Before commencing these specific exercises there are a few combinations the execution of which the student will find great use in practising for some time, (1) such words as re-

quire pairs of letters to be raised or lowered precisely to the same extent, *e.g.*, *peep, pipe, proper; tat, tit, tot, tut, state; all, ball, fall, pall, lull, hull, bull, skull, bulb; jay, joy, gay, gray, by, boy, alloy, jog, log, flag, flog; half, self, relief; lack, black, back, lily, slily, jolly, folly; quay, quagmire, quizz*, &c.

The combinations of small script letters which require the attention of writers, and ought to be frequently practised in order that familiarity with their connections and facility in their formation may be gained, may be classified as combinations consisting mainly (1) of straight lines, (2) of curved and ovalesque letters, and (3) of interrelated, curvilinear, and rectilinear characters.

Of the *first* class we may note (1) the frequently recurrent double-*f* as it appears in such words as *affair, effect, coffer, huffing, quaff*, &c., in which the chief attention should be given to making both letters precisely alike in form, and with such an exact observance of slope as shall make the main body of each of the letters perfectly parallel the one to the other; (2) the same forms with *l* added (*i.e.*, *ffl*), as they appear in *baffle, raffle, ruffle, scuffle, whiffler*, &c., in which proper parallelism is again the chief requisite; (3) *pl*, as in *place, plan, plot*; *ppl*, as in *cripple, ripple, grapple, nipple; phl*, as in *phleme* (a sharp point), *phlegm, phlogistic; lth*, in *health, wealth, stealth; phr*, in *phrase, phrenology; ttle*, as in *cattle, prattle, pottle*; and *phth*, as in *diphthong, ophthalmia, phthisis*, &c., in which the chief care requires to be given to the correlative parallel slopes, and to the differing heights of *p* and *l*, *t* and *h*, and of the keeping of *hl* and *hh* of the same up-going length. The words *half, pelf, gulph, engulpht, alphabet, fifth, twelfth, ninth, sapphic, sulphur, pamphlet, millionth, nymph, rhythm, triphthong, isthmus*, will afford good exercise in managing the complex unions possible in caligraphy.

The *second* class of difficulties in curved caligraphy consists mainly of combinations of vowels and of curvilinear consonants, in which the chief points to be taken care of are —(1) that properly equidistant spacing is observed, and (2) that the joinings of the letters are accurately and properly made, within the extent of the middle fourth of the sloped



line of the normal size of the writing, taking *i* for the measurement. Of this sort are such combinations as *eu, ue, ieu, eau; ew, ewe, iew; oa, oe, ou, owe; ee, ie, ei; igh, eigh, aigh; ey, eye; ician, itial, icient, icious, ciary, ciable; eisure, easure*, as in the words *emeute, cruel, lieutenant, beauty, screw, jeweller, review, boat, diploë, labour, shower; seen, quiet, heiress, feign, lighter, weight, straight, whey, moneyer, musician, initial, sufficient, avaricious, justiciary, sociable, leisure, measure.*

Of the *third* class of difficult combinations of curved and straight lines requiring care, and the power of readily and easily writing which is only to be attained by constant practice, we may reckon *cl* in *clad, close, clamp, uncle; dl* and *ddl* in *badly, madly, gladly, paddle, peddle, middle, muddle; gl* and *ggl* in *glee, glass, glory, haggle, smuggle, struggle; ngl* in *angle, mangle, mingle; bl, mbl*, and *bbl*, as in *trouble, feeble, tumble, crumble, pebble, stubble; kly, nkle*, and *ckle*, as in *weakly, meekly, tinkle, twinkle, trickle, buckle; cks*, as in *bricks, becks, stocks, bucks; ch, chl, lch*, and *chr* as in *church, blench, chloral, breachloader, belch, filch, pilchard, christen, chronic; ngth*, as in *length, strength; lks*, as in *talks, walks.* In all these combinations there is a tendency to crumple together, as it were, the letters into heaps, to give them too little individual space, and so to impart to such words a disagreeably conglomerated appearance. The oval of the curved letters should be made clear, plain, and full; the spaces ought to be carefully graduated so as to secure a distinct unhampered breadth and fulness of form in the words. Reference should be made to the Plate for the form and relative length of each letter, and wherever there is any difficulty in regard to the form, the directions previously given ought to be diligently re-perused and carefully followed.

A further series of useful exercises in somewhat similar combinations of curvilinear and rectilinear alphabetic forms will be found in the following list:—School, shriek, stretch, cradle, church-rate, children, sepulchral, quicklime, quagmire, quincunx, gnash, quash, squash, squalor, bulkhead, bunchlike, matchlock, upheaval, humpbacked, candlewicks, skittles, victuals, giggling, juggling, puzzling, quicksand, brindled, wrinkling, amphibious, frock-sleeve, diaphragm, antiphlogistic, scratched, hypothecation, ichthyologist, &c.

The foregoing selections of caligraphic combinations do not supply to the eye or hand the finely-flowing, easy-going forms found in ordinary copy-lines; but they will certainly insure to the real student what we presume he wants, namely, a mastery of the art of penmanship. He who has successfully managed to reproduce the letters and words here suggested will find few forms of words coming before him to demand the use of his pen which will be unfamiliar to him, or present any insurmountable difficulty. True mastery in writing is attained, not when a few cunningly arranged and readily running, pleasant-looking words or phrases can be effectively dashed off with admirable ease and exquisite dexterity, but when every required word, whatever its complications of form may be, can be deftly and pleasingly presented, and all the needful utterances of life and mind can be written readily in a fair, plain, useful style of handwriting,

"Through which the mind's all-gentle graces shine."

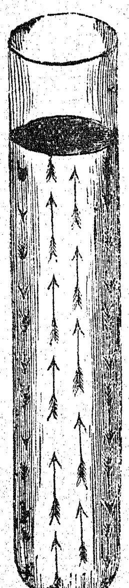
NATURAL PHILOSOPHY.—CHAPTER XX.

EBULLITION—LAWS OF EBULLITION—PAPIN'S DIGESTER—BOILING-POINT THERMOMETERS—BOILING POINTS OF WATER AT VARIOUS ELEVATIONS—BOILING POINT OF LIQUIDS—FRACTIONAL DISTILLATION—INCREMENTS OF TEMPERATURE FOR PRESSURES—BOILING POINT OF SATURATED SOLUTIONS—TINNED MEATS—INFLUENCE OF INSOLUBLE BODIES ON THE BOILING POINT—SPHEROIDAL CONDITION—CRITICAL TEMPERATURE—LIQUEFACTION OF GASES—DENSITY OF VAPOUR—RELATION OF VAPOUR-DENSITY TO MOLECULAR WEIGHT—DISSOCIATION — ANIMAL TEMPERATURES — EQUIVALENT HEAT OF DISSOCIATION — ELECTIVE AFFINITY — HYGROMETRY—HYGROSCOPES—HYGROMETERS—ABSOLUTE MOISTURE OF THE AIR.

WHEN a liquid is heated in an open vessel to a temperature such that the pressure of its vapour at that temperature is greater than the pressure at a point in the interior of the liquid, the liquid will begin to evaporate at that point, and a bubble of vapour will be formed there. This process, in which

bubbles of vapour are formed in the interior of the liquid, is called *ebullition* or *boiling*. If water is heated in the ordinary way, by applying heat to the bottom of a vessel, the lowest layer of the water becomes hot first, and by its expansion it becomes lighter than the colder water above, and gradually rises, as indicated by the arrows in fig. 1, while the colder water displaced descends by gravity to supply its place, so that a gentle circulation is kept up, and the whole water is gradually warmed, though the lowest layer is always the hottest.

Fig. 1.



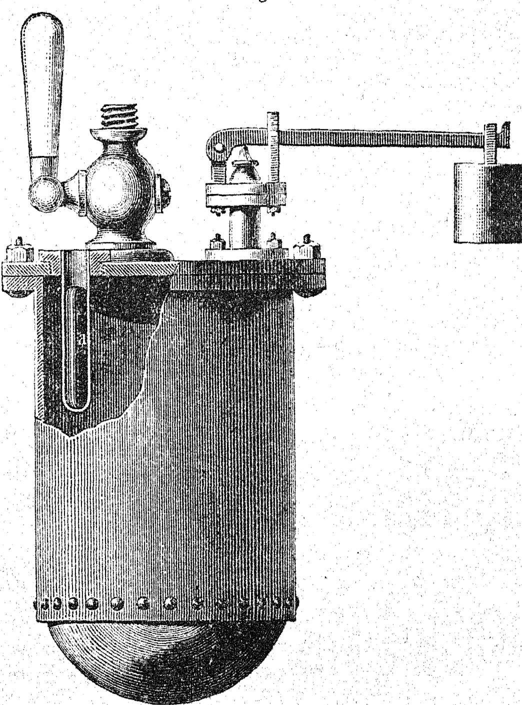
As the temperature increases, the absorbed air in the water is expelled, and rises in small bubbles without noise. When the water in contact with the bottom of the heated vessel becomes so hot that it can overcome the pressure of the atmosphere upon the surface of the water, the additional pressure due to the water in the vessel, and the cohesion of the water itself, some of it is transformed into steam, forming a bubble adhering to the bottom of the vessel. As soon as a bubble is formed evaporation goes on rapidly from the water all round it, so that it soon becomes large and rises from the bottom, but is cooled down by cooler water above it, and its sides come together or collapse with a sharp noise, which causes the *singing* noise of liquids before they begin to boil. As the water above becomes hotter, the rise of the bubbles stirs the water about much more vigorously than the mere expansion of the liquid, so that the water is soon heated throughout and brought to the boiling point, and then the bubbles enlarge rapidly, approximating nearer and nearer to complete spheres during their whole ascent, and burst into the air, throwing the water about, and producing the softer and more rolling noise of boiling. The singing noise *before* water boils is therefore due to the continual formation and collapse of steam bubbles agitating the water by a series of small explosions or shocks which communicate vibrating blows to the vessel, which in turn are communicated to the air, and from the air to the ear, and from the ear to the brain, and there translated into sound. The steam, as it bursts out of the bubbles at the surface, is an invisible gas, but when it comes into the colder air it is cooled below its condensing point, and a portion of it is formed into a cloud consisting of small drops of water which float in the air. As the cloud of drops disperses itself and mixes with the surrounding dry air, the quantity of water in each cubic foot diminishes as the volume of any part of the cloud increases, and the little drops of water begin to evaporate as soon as there is sufficient space for the vapour to be formed at the temperature of the atmosphere. Thus the cloud vanishes again into thin air.

The temperature of ebullition depends on the external pressure, on the nature of the vessel, on the substance dissolved in the liquid, and on the nature of the liquid.

The pressure of vapour during ebullition is always equal to the external pressure, and its temperature will continue to rise until that point for which the corresponding vapour pressure is equal to the external or atmospheric pressure. The temperature of the boiling point will thus be low when the pressure of the air is low, and high when this is high. It is often found that on high mountains the temperature of boiling water is too low for ordinary culinary purposes, and those who live in such places are therefore compelled to heat water in a closed vessel under a pressure greater than that of the atmosphere, in order to cook their food. Papin, a French physician, invented an apparatus for this purpose, known as Papin's Digester, shown in fig. 2. It consists of a strong closed vessel to contain the water to which heat is to be applied. When the pressure rises too high, the vapour escapes by means of a safety valve; a limit is thus placed beyond which the pressure and temperature cannot mount, but this limit is sufficiently high to permit the contained water performing the necessary operations. Such vessels are used in the extraction of gelatin from bones, &c.

Boiling-point thermometers are sometimes employed for determining, by means of the temperature of ebullition, the pressure of the air, and thus indicating the heights of mountains. Such instruments are more portable than a barometer;

Fig. 2.



their scale embraces a temperature range of about 20° below 100° C., to a few degrees above this point. The temperature of the boiling point may therefore be very accurately observed.

In the same manner water will boil in the exhausted receiver of an air-pump at 21·1° C., or the ordinary temperature of water in summer. The *vacuum pans* used in the concentration of cane juice and the evaporation of syrup effect a considerable improvement in the manufacture and refining of sugar, as they enable the water to be driven off at a temperature below that at which the sugar becomes partially carbonized or darkened in colour, and rendered treacly.

The following table gives the boiling points of water at various elevated places.

	Height above Sea. Feet.	Mean height of Barometer. Inches.	Boiling point, Centigrade.
Summit of Mont Blanc, . .	——	——	85°
Farm of Antizana, ...	13,455	17·87	86·1°
Town of Micuipampa (Peru),	11,870	19·02	87·7
Quito, ...	9,541	20·75	90·0
Town of Caxamarca (Peru), .	9,384	20·91	90·3
Santa Fé de Bogota, . . .	8,731	21·42	90·8
Mexico, ...	7,471	22·52	92·2
Hospice of St. Gothard, . .	6,808	23·07	93·0
St. Rémi, ...	5,265	24·45	93·3
Briançon, ...	4,285	25·39	95·0
Pontarlier, ...	2,717	26·97	96·8
Madrid, ...	1,995	27·72	97·7
Innspruck, ...	1,857	27·87	97·8
Munich, ...	1,765	27·95	97·9
Neufchatel, ...	1,437	28·31	98·3
Geneva and Friburg, . .	1,221	28·54	98·4
Moscow, ...	984	28·82	98·8
Vienna (Danube), ...	436	29·41	99·3
Paris Royal Observatory, .	213	29·69	99·7

The boiling point, or that temperature at which the bubbles of vapour rise through a liquid without condensation, varies greatly with the composition of the liquid.

Substance.	Boiling Point.	Substance.	Boiling Point.
Nitrous oxide,	−92° C.	Acetic acid,	117·3°C
Carbonic acid,	−82	Amylic alcohol,	131
Ammonia,	−39	Propionic acid,	137·2
Cyanogen,	−20	Butyric acid,	156·3
Sulphurous acid,	−10	Turpentine,	160
Ethylic chloride,	+11	Iodine,	175
Hydrocyanic acid,	25·6	Aniline,	182
Ether,	37	Naphthaline,	212
Bisulphide of carbon,	46·8	Benzoic acid,	245
Bromine,	59·6	Phosphorus,	290
Chloroform,	62	Linseed oil,	316
Methyl alcohol,	65·5	Strong sulphuric acid,	318
Nitric acid,	66	Mercury,	358
Common alcohol,	74·3	Sulphur,	446
Benzole,	80·4	Selenium,	665
Chloral,	94	Cadmium,	860
Water,	100	Zinc,	1040
Formic acid,	100		

By the above table it will be seen that the boiling point of some liquids is below the freezing point of water.

When several liquids with different boiling points are mixed they may be successively separated by first raising the liquid to the lowest boiling point and keeping it at this temperature until boiling ceases, then raising it to the next boiling point, and so on. This is termed *fractional distillation*, and is commonly employed in the separation of natural mixtures of volatile oils.

As the boiling point of water rises when the pressure on its surface is increased, the following table gives the increase of heat necessary to overcome an equal additional pressure, by which it will be seen that a very small increase of heat only is necessary. This is the chief cause of the economy of high-pressure steam-engines as compared with those working at lower pressures.

Pressure in atmospheres of 30 inches of mercury.	Temperature in degrees Centigrade.	Rise of temperature for each additional atmosphere.
1	100° C.	—
2	120·8° C.	20·8°
3	134·5	13·7
4	144·0	9·5
5	152·2	8·2
6	159·0	6·8
7	165·3	6·3
8	170·8	5·5
9	175·7	4·9
10	180·3	4·6
11	184·5	4·2
12	188·4	3·9
13	192·1	3·7
14	195·5	3·4
15	198·8	3·3
16	201·8	3·0
17	204·8	3·0
18	207·6	2·8
19	210·4	2·8
20	213·0	2·6

The boiling point of a liquid is raised when it holds any considerable amount of a solid in solution, provided that the substance be less volatile than the liquid itself. During ebullition the pure water alone is evaporated, leaving the substance in solution behind.

This property of the higher boiling point of saline solutions enables a water bath to be obtained at any of the fixed temperatures indicated. In the preparation of Australian and American tinned meats, it is necessary to drive out all the air from the meat and its juices by long boiling before the tin is closed, in order to preserve the contents from putrefaction, and as the boiling point of the juice of the meat is considerably above 100° C., a large bath is made of chloride of calcium, in which the tins containing the meat are immersed, having been previously soldered down, and only a small perforation left in the centre of the lid. The bath is then raised to about 179·4° C., when the contents of all the tins boil steadily, the steam issuing from the small hole. From the appearance of the steam the complete expulsion of all the air is determined, and then a drop of melted solder is skilfully placed on the small hole, and thus sealed the tins are removed. The overcooking, which is the only fault of meat thus preserved, is due to the long boiling necessary for the complete expulsion of the air: if this is not effectively performed putrefactive gases are developed, and the tins become what is termed "blown."

The following table gives the boiling points of water when saturated with the salts named:—

BOILING POINTS OF SATURATED SOLUTIONS.

Name of Salt.	Boiling point in degrees Centigrade.	Percentage of salt in the solution.
Nitrate of soda,	121·1°	224·8
Nitrate of ammonia,	—	unlimited
Nitrate of potash,	115·5	335·1
Chloride of sodium (common salt),	108·3	41·2
Chloride of potassium,	108·3	59·4
Chlorate of potash,	115·5	61·5
Carbonate of soda,	104·4	48·5
Acetate of soda,	124·4	209·0
Chloride of barium,	104·4	60·1
Tribasic phosphate of soda and water,	106·6	112·6
Sal ammoniac,	114·4	88·9
Chloride of calcium,	179·4	325·0
Acetate of potash,	168·8	798·2
Nitrate of lime,	151·1	362·2
Chloride of strontium,	117·7	117·5
Carbonate of potash,	135·0	205·0

The temperature at which different liquids boil varies greatly. Acids in solution present similar results; but substances merely mechanically suspended in the liquid, such as earthy matters, bran, shavings, &c., do not change the boiling point. Water that has been previously boiled, when covered with a layer of oil, may be raised to 120° C. without boiling, but at a higher temperature it suddenly begins to boil with great violence.

When a liquid is suspended in another of similar specific gravity, but of a higher boiling point, with which it does not mix, it may be raised considerably above its boiling point without the formation of any vapour. At such high temperatures, the contact of a solid body, or the production of gas bubbles in the liquid, produces a sudden vaporization of the liquid accompanied by a sound similar to the hissing of a hot iron.

SPHEROIDAL STATE.

When a drop of water or other liquid is thrown upon a surface heated to a very high temperature, the liquid does not adhere to the heated surface, but forms a spheroidal mass, which keeps oscillating and moving about, evaporating at the same time so as to be reduced in volume without boiling. This phenomenon was first discovered by Leidenfrost more than 100 years ago, and has been named after him. The subject has more recently been investigated by Boutigny. If a fairly thick silver or platinum dish be heated to redness, and a little warm water carefully dropped into the dish by means of a pipette, the liquid will not spread out over the dish, or moisten it, as it would at an ordinary temperature, but at once assumes the form of a flattened globule, that is, passes into the spheroidal condition, and rotates rapidly on the bottom of the hot dish; not only does it not boil but it evaporates very slowly, only about one-fiftieth as rapidly as if it boiled. As the dish cools a point is reached at which the temperature is not high enough to maintain the spheroidal state; the liquid then moistens the dish, and a violent ebullition at once ensues, and rapid evaporation. All volatile liquids are capable of assuming the spheroidal state, and the

temperature at which it can be produced varies with each liquid, being higher as the boiling point of the liquid is raised. A temperature of 200° C. is necessary for water to assume the spheroidal state, for alcohol 134° C., for ether 34° C., and for liquid sulphurous acid 11° C. When a liquid is in the spheroidal state its temperature is always below that of ebullition. Boutigny found that the temperature of water in this state was 95° C., alcohol 75° C., ether 34° C., and liquid sulphurous acid − 11° C. The temperature of the vapour disengaged he found to be as high as that of the vessel itself. By means of this property of liquids in the spheroidal state remaining below their boiling point, Boutigny was able to freeze water in a red-hot crucible. Heating a platinum vessel red-hot, a small quantity of sulphurous acid was introduced into it, which immediately assumed the spheroidal condition, with a very slow evaporation, its temperature being about − 11° C.; on adding a small quantity of water the spheroidal state was destroyed and evaporation suddenly became so rapid that a portion immediately solidified, and a small piece of ice could be removed from the red-hot vessel. In the spheroidal state the liquid is not in contact with the heated surface, but appears to rest upon a cushion or film of its own vapour, produced by the heat radiating from the heated surface against its under side; as fast as this vapour escapes from under the globule its place is supplied by a fresh layer formed in the same manner, so that the globule is constantly buoyed up by this vapour, and is prevented from coming into actual contact with the heated surface.

The phenomenon of the spheroidal state explains why it is that the hand may be dipped rapidly into molten lead without injury. It is, however, necessary that the liquid metal be heated considerably above its solidifying point, and that the hand be previously carefully wiped over with a damp cloth. In consequence of the great heat the hand becomes covered with a layer of spheroidal fluid which prevents the contact of the metal. Radiant heat alone comes into operation, and this is mostly expended in forming aqueous vapour on the surface of the hand. When the hand is immersed in boiling water, the water adheres to the skin, and a scald is produced.

CRITICAL TEMPERATURE.

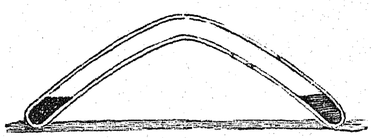
The tension of vapour from water boiling at 100° C., under atmospheric pressure of 30 inches of mercury, is exactly equal to that of the atmosphere; this is expressed in the following terms:—*A liquid boils when the tension of its vapour is equal to the pressure which it sustains.* Therefore as the pressure increases or diminishes, the tension of its vapour will increase or diminish, and also the temperature necessary to produce ebullition. Every liquid therefore has a number of boiling points dependent upon pressure.

As the increment of temperature which is required to overcome a stated increase of pressure has been shown by a previous table to be continuously reduced, Dr. Andrews has demonstrated that there exists for every liquid a temperature at which no further amount of heat is required to boil it under additional pressure, and that there is consequently a point where the gaseous state remains absolute. This point is termed the *critical point*, or *critical temperature*. At this temperature and pressure the substance is in a state partaking of the character of both liquid and gas, or the gaseous and liquid states become continuous, or run into each other without any sudden break such as occurs in the boiling of water. Below this critical point a sudden transition from gas to liquid is accompanied by a sudden contraction of volume, and liquid and gas are separated by a defined line of demarcation. Above this point the change is connected with a gradual and almost imperceptible diminution of volume.

LIQUEFACTION OF GASES.

Some gases may be caused to assume the liquid form by their affinity for a liquid. When ammoniacal gas is brought into contact with water it is immediately dissolved; the same with hydrochloric acid and other gases. The condensation of gases without the aid of a chemical solvent is much more difficult, but by the employment of immense pressure and cold, the gases formerly called permanent have yielded to the combined effects of these two agents. For some time it was considered impossible to obtain either in a liquid or solid form the gases, oxygen, hydrogen, nitrogen, nitric oxide, carbonic oxide, and marsh gas, but the researches of Cailletet and Pictet have shown that the distinction *permanent* gas no longer exists, and that all may be liquefied under proper conditions. Faraday was one of the first who succeeded in liquefying gases by the combined application of cold and pressure. His method consisted in placing the materials for producing the gas in the two ends of a strong bent glass tube, fig. 3, and then

Fig. 3.



hermetically sealing the end. The materials are made to pass into one end, and the action then commencing, the gas given off accumulates, and in proportion as it is disengaged its pressure increases, and it ultimately liquefies and collects in the opposite leg, more especially if its condensation is assisted by placing the leg in a freezing mixture. The pressure in the tube may be ascertained by placing a small manometer in the apparatus. Cyanogen gas is liquefied by heating cyanide of mercury in a bent tube of similar form, and carbonic acid by heating bicarbonate of sodium. Other gases have been condensed by using special reactions. Thus chloride of silver absorbs about 200 times its volume of ammoniacal gas; when the compound thus formed is placed in one leg of the tube and gently heated, the other leg being cooled in a freezing mixture, a quantity of liquid ammoniacal gas collects in the cooling leg. When carbonic acid has been liquefied, and is permitted to escape into the air, a portion only of the liquid volatilizes; in consequence of the heat absorbed by this evaporation, the rest is so much reduced in temperature as to solidify in white flakes like snow. Solid carbonic acid evaporates very slowly, and its temperature has been found to be about − 90° C. To the touch it does not produce the sensation of such great cold, owing to imperfct contact; but if the solid be mixed with ether the cold produced is so intense that a little placed on the skin produces all the effects of a severe burn. A mixture of solid carbonic acid and ether will solidify four times its weight of mercury in a few minutes. If a tube containing liquid carbonic acid is placed in this mixture, the liquid becomes solid and resembles a transparent piece of ice.

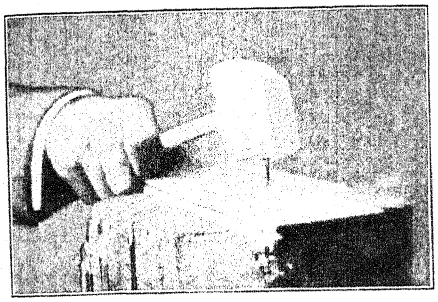
Loir and Drion utilized the cold produced by the evaporation of ether in the liquefaction of gases. A current of air from a blowpipe bellows passing through several tubes into a few ounces of ether produced a temperature of − 34° C. in five or six minutes, and by evaporating liquid sulphurous acid in the same manner − 50° C. is obtained. When liquid ammonia is rapidly evaporated in the presence of sulphuric acid under the air-pump, a temperature of − 87° C. is obtained, sufficient for the liquefaction of carbonic acid under ordinary atmospheric pressure.

DENSITY OF VAPOUR.

The relation between the weight of a given volume of a vapour and that of the same volume of air is the *density of a vapour*. If w be the weight of the vapour in grains, v its volume in cubic inches, and t its temperature; and if H be the height of the barometer, and h that of the mercury in the gas tube, the pressure on the vapour will be $\mathrm{H} - h$.

If it is required to find the weight w of a volume of air v, at the temperature t, and under a pressure $\mathrm{H} - h$. At zero, under a pressure of 760 millimetres, a cubic inch of air weighs 0·31 grains; therefore under the same conditions, v cubic inches will weigh 0·31 v grains, and therefore the weight of v cubic inches of air at $t°$, and the pressure 760 millimetres, is $\frac{0{\cdot}31v}{1+at}$.

As the weight of a volume of air is proportional to the pressure, the above weight may be reduced to the pressure $\mathrm{H} - h$ by multiplying $\frac{\mathrm{H}-h}{760}$, which gives $\frac{0{\cdot}31v(\mathrm{H}-h)}{(1+at)760}$ for the



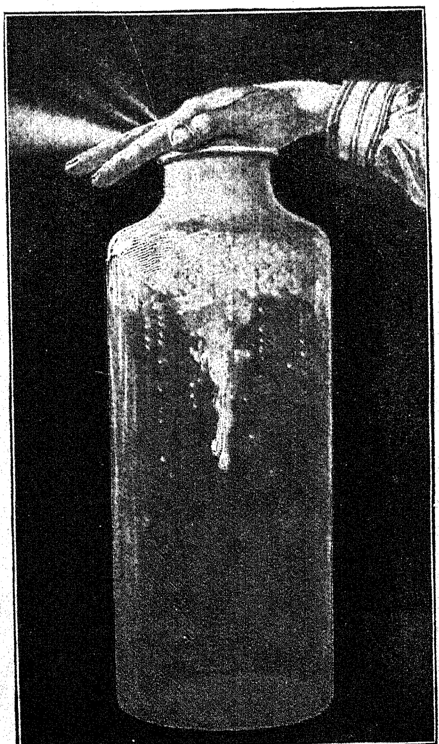
Driving a nail with a hammer made of mercury frozen by liquid air.

Burning steel in an ice tumbler partly filled with liquid air.

The steel is burning at 3500° F. in an ice receptacle containing liquid air in combustion.

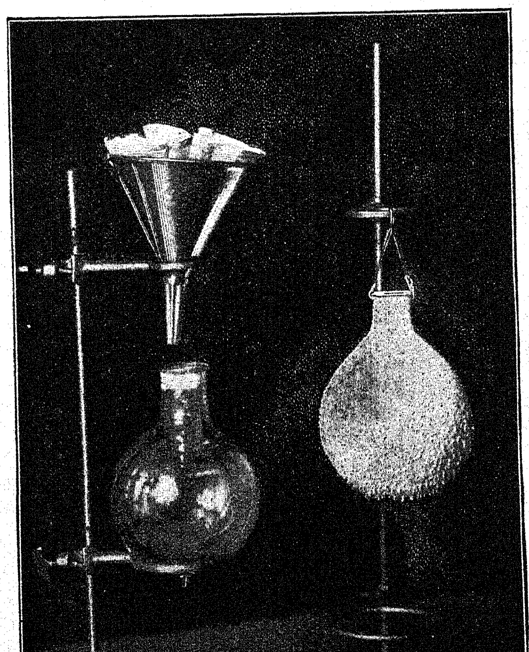
Compared with liquid air (temperature 312° below zero), ice at 32° F. is as hot as a furnace, and produces the same effect on the former as a hot fire on water.

Liquid air boiling on a block of ice.



Liquid air in water.

The silvery bubbles are liquid oxygen; the nitrogen boils away.



Filtered liquid air in a Dewar bulb and liquid air in an ordinary glass bulb.

The Dewar bulb is composed of two bulbs with a vacuum between, which prevents the passage of heat, and thus protects the liquid air so that it vaporizes very slowly. The unprotected bulb has collected a coating of frost.

weight w' of the volume of air v under the pressure $H-h$ and at $t°$. Therefore the density $D=\frac{w}{w'}=\frac{w(1+at)760}{0{\cdot}31v(H-h)}$.

The law which governs the densities of vapours determined at temperatures a few degrees above their boiling points (where they are perfect gases) is very important in chemistry, in fixing the molecular weights of bodies, and especially in organic chemistry.

The law is, that *the densities of vapours are proportional to their molecular weights.* If the density of air is taken at 1, that of hydrogen is 0·0693, equal to $\frac{1}{28{\cdot}86}$ of the molecular weight. When both densities and molecular weights are referred to the same standard, that of hydrogen being taken as 2, the *vapour densities are equal to the molecular weights.*

DENSITY OF VAPOURS.

Air, ...	1·0004	Vapour of carbon bisulphide, .	2·6447
Vapour of water, .	0·6225	" phosphorus,	4·3256
" alcohol, .	1·6138	" turpentine,	5·0130
" acetic acid,	2·0800	" sulphur, .	6·6542
" ether, .	2·5860	" mercury, .	6·9760
" benzole, .	2·7290	" iodine, .	8·7160

DISSOCIATION.

In some cases exceptions arise. When sal-ammoniac (NH_4Cl) is strongly heated, it is resolved into ammonia (NH_3) and hydrochloric acid (HCl), and in that case it occupies twice the volume required by the law. But even at temperatures below this there is a partial decomposition, so that the vapour consists of molecules of sal-ammoniac mixed with molecules of free hydrochloric acid and of free ammonia. The amount of decomposition depends on the temperature, but for the same temperature the amount decomposed is in a constant ratio to that temperature. In such cases the vapour density is termed *abnormal,* and this partial decomposition, in which there is a mixture of combined and uncombined molecules, is termed *dissociation.*

The antagonism of heat to the selective force which urges dissimilar bodies to combine with each other, and the energy which binds them together as a chemical compound, is well illustrated by water. The solid ice is loosened and converted to the state of liquid water by the conversion of 79·25° C. of temperature into constituent repulsive energy. This liquid again becomes a gas by the appropriation, for the purposes of its own constituent repulsive energy, of 550° C. of temperature. By increasing the temperature, Deville has shown that the constituents of the compound gas may be driven asunder, and its hydrogen and oxygen, which at ordinary temperatures are so firmly united by the power of chemical affinity, separated from each other.

Not only is a higher temperature necessary for the more advanced stage of repulsion, but a larger amount of heat is rendered latent in performing the work. If the vapour of water be heated to, say, 1000° C., dissociation takes place, and continues until the separated gases, the hydrogen and the oxygen, have reached a certain tension and are diffused in a certain proportion through the vapour of water; no further dissociation then takes place. If the temperature be increased to 1200° C., further dissociation occurs, and the separated gases diffuse themselves in the vapour until a higher tension is reached, and so on. Therefore there is a *tension* of dissociation corresponding to each degree of temperature.

If an atmosphere of steam containing dissociated gases of a given tension be reduced to a temperature below that corresponding to this tension, re-combination takes place simultaneously and continuously with the reduction of temperature. Owing to the great difficulties of quantitive analysis at very high temperatures, no very reliable temperatures and tensions of dissociated gases have been tabulated, but generally speaking, the temperature at which water is dissociated—and the dissociated elements remain separate at a tension corresponding to that of ordinary atmospheric pressure—is from 2500° C. to 2800° C.

The amount of latent heat absorbed in the act of the dissociation of water may be approximately estimated at 2153 calories, that is, sufficient heat to raise the quantity of liquid water decomposed 2153° C. The specific heat of steam being rather less than half that of water, $\frac{475}{1000}$, this would abstract from the vapour that is directly decomposed 4532° C. When steam is condensed to water, the whole of the latent heat (550° C.,) absorbed in its evaporation is set free; in the same way the 4532° C. of latent heat are set free on the re-combination of the elements of water. When the elements of a single grain of water are mixed at any ordinary temperature, they remain mechanically mixed without combination, but if heated by the contact of a flame or electric spark, they instantly combine with a loud explosion and burst of flame. Carbonic acid is likewise dissociated similarly to water, and its elements on re-combining give out the same amount of latent heat that they had converted into repulsive energy in their dissociation, and this amount of heat is likewise so great as to produce flame and explosion. The ordinary combustion of the fireplace, of candles, lamps, and gas lights, is simply the restoration of the latent heat of the long-ago dissociated elements of carbonic acid and water.

The vapour of water is largely diffused throughout the atmosphere, together with a small proportion of carbonic acid gas, in the vast laboratory of nature. These compounds are dissociated by the action of the solar rays, and the agency by which this dissociation takes place at so low a temperature is vegetable life. Every advance in the growth of a tree, plant, or flower, is the result of the dissociation of water and carbonic acid into the hydrocarbon materials, which form the vegetable tissues, and free oxygen gas is given off in immeasurably small quantities, from every vegetable cell that contains the green sap of the plant when exposed to light and warmth.

The solid and liquid results of this dissociation form that portion of the plants consumed by animals for food, which by recombination in our bodies restores the latent heat of dissociation, and serves to maintain the internal warmth necessary to animal life. The other or gaseous element of this dissociation, the liberated oxygen, forms the vital air breathed to support life. Thus the economy of life is continually restored and maintained; the vegetable kingdom dissociates, the animal recombines, and the loss of latent heat or temperature that accompanies vegetable growth is restored by the evolution of sensible heat, a primary function of animal life. Every growing plant and vegetable, by abstracting heat, cools the air and water around, while every animal warms it, and restores the heat abstracted from the solar rays by the plant. The living animal body is rarely of the same temperature as the surrounding air; the animals of the polar regions are much warmer than the ice on which they dwell, while those of the equatorial regions are colder than the air which they breathe. Birds have not the same temperature as the atmosphere in which they fly, nor fishes that of the water in which they live. Descending to the reptile class, the temperatures of the medium and of the animal nearly coincide. The temperature which the human body maintains, is the same, whether breathing the polar atmosphere at several degrees below zero, or when scorched by a tropical sun with the thermometer 37·7° C. in the shade.

Countless ages since, the solar rays shone upon the primeval forests of Great Britain and the earth; the carbonic acid and water of that ancient atmosphere were dissociated into hydrocarbons and free oxygen, a large amount of solar energy being absorbed as latent heat from the sun's rays. The heat thus solidified in process of time became buried beneath the mud and earth deposited by the turbid waters that covered the fallen tree trunks, and there it still remains, preserved for our use until it is dug up in the form of coal and re-dissociated into carbonic acid and water, and yields the radiations of our furnaces, fireplaces, and gas lights. All the light and heat that is obtained from coal is simply the restored energy of the latent heat of the solar rays absorbed millions of years ago. The amount of sensible heat given out by the combustion of an entire tree is exactly equivalent to that which it absorbed from the solar rays during the period of its growth, just as the heat evolved in the condensation of a vapour, or the solidification of a liquid, is equivalent to that which was rendered latent during the evaporation

or the liquefaction of the substance into a gas or a liquid. Volatile oils, as turpentine, may be evaporated by boiling, and then re-condensed by cooling. The fixed oils, on account of their temperature of dissociation being below their boiling points at ordinary atmospheric pressure, just as they begin to boil become darker, their constituents, carbon and hydrogen, separate more or less completely, and instead of evaporating there remains a pitchy material, which finally becomes a mass or coke or carbon. In some cases the fixed oils, as glycerin, may be distilled by removing the pressure of the atmosphere, which lowers the boiling point without lowering the point of dissociation. Burnt sugar, barley sugar, and caramel are examples of dissociation. Sugar is composed of carbon and the elements of water. When a substance, such as concentrated sulphuric acid, that has a stronger affinity for the water than the carbon of the sugar, is added to powdered sugar, the latter darkens. The combination between the sulphuric acid and the water being very energetic, a considerable amount of latent heat is evolved, and a cinder of separated carbon remains in place of the sugar; the strong chemical attraction of the acid for the water overpowering the weaker chemical attraction of the carbon for the water, is termed *elective affinity*.

If the same kind of sugar is taken as dry as possible and heated in a vessel, it fuses and becomes yellow, the vapour of water being driven off, and forms barley sugar, or sugar dissociated sufficiently to lose some of the properties of pure sugar, principally as regards its crystalline structure, the yellow colour being due to the separated carbon. By continuing the temperature more and more vapour of water is separated, and more and more carbon is dissociated, as is shown by the colour assuming a red orange, deep red, a red brown, a dark brown, and finally a black charcoal or coke, in proportion as the water has been dissociated from the carbon. This is simple dissociation by the expansive power of heat. If a few crystals of blue vitriol, which is composed of sulphate of copper and water, are broken up and heated in a test tube, vapour of water is given off, and a white powder remains which is anhydrous or waterless copper sulphate. If this is allowed to become cool and a few drops of water are added, the water combines, and the blue colour is restored. If a thermometer is applied, it will register the evolution of as much sensible heat as had been converted into separating energy during dissociation. At a still higher temperature the white anhydrous sulphate may be converted into black oxide of copper by the dissociation in vaporous form of the anhydrous sulphuric acid. All chemical compounds are probably dissociable by heat, as all elementary solids, such as metals, are fusible and evaporable if subjected to a sufficiently high temperature.

Hygrometry is that branch of science which treats of the state of the air with regard to moisture. This condition of the atmosphere is one of the elements which form the climate of a place, and as the human frame is very sensitive to the hygrometric state of the air, the subject is one of considerable practical importance. At one time the air is excessively dry, and at another it is fully saturated with moisture; and it varies in every possible degree of humidity between those extremes. This variable condition is ascertained by means of instruments termed *hygrometers*. (See page 798.)

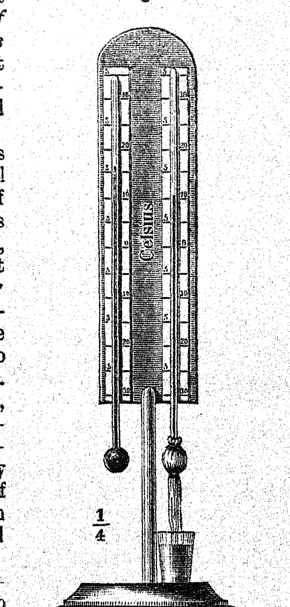
There are several facts regarding the vapour present in the air which it is very necessary to ascertain. One of these is its pressure. If a cubic foot of air be isolated in a vessel and allowed to remain at its normal temperature and pressure, and then a substance which absorbs moisture is introduced into the vessel, the air will be rendered dry, and its pressure will be reduced by an amount representing the pressure of aqueous vapour present in the air. It is necessary to ascertain what this pressure is, for upon this, among other things, depends the behaviour of the air when cooled down. If at the higher temperature there be present nearly as much aqueous vapour as the air can contain at that temperature, then when the air is cooled down only a few degrees some of this vapour will be deposited in the liquid or solid state; the temperature at which this condensation takes place determines the dew-point. Consequently, if the pressure of vapour in the air at its existing temperature be great, the dew-point will be high, but if this pressure be small, the dew-point will be low in the thermometric scale.

It is also necessary to ascertain the relative humidity of the air. All substances exposed to the air become affected by the deposition of moisture when the dew-point is reached, and many substances will be affected long before this takes place; the human body, for instance, will be sensitive to the dampness of the air long before. If, however, the present temperature of the air be far above that of deposition, the air is said to be dry. Therefore the sensation of dryness or wetness does not depend upon the *absolute* amount of aqueous vapour present in one cubic foot of vapour, for if the temperature be very low, although the air may not contain much aqueous vapour, yet this vapour may approach very closely to the maximum amount which can be retained at the temperature, and the air is said to be wet. But if the same mixture of air and vapour be warmed up several degrees, the vapour will represent only a small fraction of the total amount which can be retained at the higher temperature, and hence the air will feel very dry. When this high temperature is produced by a stove, it is usually necessary to place near the stove a vessel containing water in order to augment the amount of aqueous vapour present in the air and compensate its dryness. This dryness or dampness of the air is termed its *relative humidity*. Relative humidity therefore is the fraction expressing *the ratio between the amount of vapour actually present in the air at a given temperature, and the greatest amount of vapour which it can contain at that temperature.* The greatest amount, or complete saturation, is taken as 100, and 20, 30, 40, 50, &c., will denote that the air contains 20, 30, 40, 50, &c., per cent. of the maximum which can held in suspension at that temperature.

To ascertain accurately the condition of the air, it is also necessary to know the weight of vapour present in a given volume of air, and likewise the entire weight, or specific gravity, of a given volume of air. This last element is essential, as a body weighed in air is always lighter than if weighed in vacuo by the weight of its own bulk of air.

The *hygrometric* quality of the air, or *the ratio between the weight of one cubic foot of air and that of the aqueous vapour present in it*, must therefore be accurately determined for all meteorological purposes.

Fig. 4.



There are various methods of ascertaining in a general way the dryness or wetness of the air. Some substances have a great affinity for water, and readily deliquesce, so that if the air be very dry they remain a long time comparatively unaffected, but if the air is moist they rapidly absorb the moisture and deliquesce. Other substances, such as hair, elongate when moist, and contract again when dry. Saussure made use of this property of hair in the construction of his *hygroscope*. Catgut again untwists when moist, and twists again when dry.

The wet and dry bulb hygrometer was devised by Mason upon the principle that the more nearly the air is saturated the more slowly the process of evaporation proceeds, and that no evaporation whatever takes place when the saturation is complete, and that the rate at which evaporation proceeds bears a fixed relation to the reduction of temperature induced.

The apparatus (fig. 4) consists of two delicate mercurial thermometers, the bulb of one of which is kept constantly moist, by a few threads looped round it, and dipping into a

glass of water, while the bulb of the other is dry. The wet thermometer always denotes a lower temperature than the other (unless when the air is fully saturated with moisture), and the difference of temperature shows the rate of evaporation going on. In making an observation the apparatus is generally placed in an open window where there is a slight current of air.

The absolute moisture of the air varies with the temperature, both in the course of the year and of the day. In summer, as the ascending currents of air carry the moisture into the higher regions, there is a minimum at 3 p.m. and at 3 a.m., and a maximum at 8 a.m. and 8 p.m.

In the tropics the *absolute* moisture is greatest, representing a pressure of $25^{mm.}$; in the latitude of Great Britain it does not exceed $10^{mm.}$ The relative moisture varies in different regions; in the centre of continents it is greater than on the sea or sea-coasts, and is at its maximum in the hottest, and at its minimum in the coolest part of the day. The clear skies of continental regions show that the dryness increases with the distance from the sea. In North America, where the south-west wind traverses large tracts of land, the relative moisture is less than in Europe, and evaporation is much more rapid; clothes speedily dry, and English pianos soon give way, while those sent over from America to Europe are very durable, from the natural seasoning of the wood, maintaining their tone and the tension on the frame for a lengthened period.

LOGIC.—CHAPTER IX.

SYLLOGISTIC FORMS—MOODS, FIGURES, AND THEIR LAWS—TABLES OF THEIR COMBINATIONS AND ILLUSTRATIONS OF THEIR VALIDITY.

The convincing *form* of the syllogism gives importance to its usefulness. The merit of a reasoner consists not in his ability to draw a conclusion from given (*i.e.* accepted or advanced) premisses, but in his power of selecting that form of presenting the premisses given in which they will yield the largest, the most trustworthy, the most indubitable, and the most pertinent and important conclusion. Logical genius displays itself at its highest and best when it realizes that combination of known (proved or admitted) truths which every intelligent man can follow and, when put together in legitimate syllogistic form, see its conclusiveness. The logician moulds his arguments so that they can be presented to the mind not in the abstruse finely balanced numericalism of the mathematician, or the minutely differentiated technicalism of the scientist—which in the course of an investigation are requisite and imperative—but in the common forms of thought which ordinary men employ, can understand, and must regard as valid. Nature makes every man a logician, as it makes every man a most admirable piece of working machinery ; but skill in the use of the bodily frame requires that we should know the motions of bone and muscle which are useless in one form, of little or no service when employed in one way, and almost all-powerful when rightly used, according to the special circumstances which arise. This, those can best do who best know the entire range of those powers, what they are each best adapted for, and what they are each least fitted to accomplish ; and though, in this as in many things, "instinct is a great matter," yet apprenticeship, discipline, and drill are not generally regarded as ineffective or invaluable. The true excellency of logic is that it economizes effort of thought and yet increases its power of effectiveness. Thus, it shows us truly that, as there are *four* kinds of propositions, denoted by the letters A, E, I, O, and *three* propositions in each syllogism, the number of (possible) moods must correspond with all these possible ways of combining these four kinds of propositions, and consequently their (representative) letters by threes. A simple computation shows that these possible combinations must altogether amount to sixty-four; for *any one* of these four propositions may be the major premiss; and *each* of these four majors may have four different minors; this gives sixteen pairs of premisses, each of which may have four different conclusions, amounting in the whole to sixty-four different syllogisms, all of which may be formed by different combinations of three terms thrown into triplets of propositions varying in quantity and quality.

But all these combinations of propositions, though possible, are not advisably available in practice; they are found to violate some of those dominant conditions of reasoned thought, incorporated in the logical rules which we explained in the preceding chapter. It cannot fail to be seen at a glance, for example, that the moods represented by I I I, I O O, and O O O, must be rejected from valid and useful forms of reasoning, from each having two *particular* premisses, and thereby violating Rule VII., that "from two particular premisses nothing can be proved." In the same way, that sort of proposition which is indicated by E E E must be rejected, because it violates Rule III., that "from two negative premisses nothing can be concluded." So I E O becomes invalid because it involves an *illicit process* of the *major* term, as explained in Rule II. By examining all the possible combinations, and comparing them, respectively, with the rules of right reason placed before the student in Chapter VIII., it is found that a great majority of them are useless, and that practically, of the whole sixty-four, there remain but *eleven* moods which can be used with propriety and advantage in the construction of legitimate syllogisms such as are effective in carrying conviction to the general mind, looking at the form in which the reasoning employed is cast.

The Eleven Practical Moods may be numerically represented by the following arrangements of denotive letters, viz.:—

A A A (1).	A I I (1, 3).	E I O (1, 2, 3, 4).
A A I (3, 4).	A O O (2).	I A I (3, 4).
A E E (2, 4).	E A E (1, 2).	O A O (3).
A E O.	E A O (1, 3, 4).	

[The numbers included in brackets indicate the *figures* in which these words yield valid and useful syllogisms.]

The result is therefore that out of 64 possible moods, 53 are excluded, and 11 alone are really found to be forms issuing in valuable and truly valid processes of reasoning. It does not follow, however, that because in these eleven moods syllogism is possible, the rules of syllogism are even in these necessarily observed, and their use in every circumstance fully valid. On the contrary, only in A E O and E I O are true conclusions deducible in all the four figures. In all the others paralogism (*i.e.* the drawing of a conclusion from premisses which do not really warrant it) is possible. In some of the moods we have only one distributed term, and in others, although we have two or more, unless the positions of these terms are such as to fulfil the laws determinative of the distribution of the middle term, and of avoiding the recurrence of an illicit process, fallacious reasoning may still be the result.

Remembering that the *matter* of a syllogism is the statement contained in its three propositions; that the *form* of a syllogism is the disposition and place of these three propositions according to mood and figure; that *mood* is the arrangement of propositions according to quantity and quality; and that *figure* signifies the special form which a syllogism takes, according to the place which the middle term occupies, we can easily satisfy ourselves that in the first figure there can be only four legitimate moods ; in the second, four ; in the third, six ; and in the fourth, five ; making a total of nineteen, according to the usual formal logic. In every universal affirmative proposition, A, the subject, is distributed, and the predicate undistributed. In every universal negative proposition, E, both the subject and the predicate are really distributed. In every particular affirmative proposition, I, both the subject and the predicate are really undistributed, In every particular negative proposition, O, the subject, is undistributed, and the predicate distributed. In consequence of these definitive facts, A A A, A O O, and O A O are excluded from *three* figures ; AEE, AEO, AII, EAE, IAI, from *two;* A A I, from *one;* that is, a total of twenty moods. The reasons for these exclusions may be given briefly. (1) Because they present the middle term undistributed, the first figure excludes I A I and O A O ; the second, A A A, A A I, A I I, and I A I ; and the fourth, A I I and A O O. (2) Because presenting an illicit process in the major term,

TABLE OF VALID CATEGORICAL SYLLOGISMS,

TOGETHER WITH AN INDICATION OF THE GROUNDS OF THE INVALIDITY OF UNACCEPTED FORMS.

The Form of the Moods.	The Signs of the Moods.	I. *M*..........P. S..........*M*. S..........P.	II. P..........*M*. S..........*M*. S..........P.	III. *M*..........P. *M*..........S. S..........P.	IV. P..........*M*. *M*..........S. S..........P.
Dis. Und. Dis. Und. Dis. Und.	A A A. Barbara.	VALID.	Undistributed. Middle.	Illicit. Minor.	*Illicit. Minor.*
Dis. Und. Dis. Und. Und. Und.	A A I. Darapti. Bramantip.	VALID (but useless).	Undistributed. Middle.	VALID.	VALID.
Dis. Und. Und. Und. Und. Und.	A I I. Darii. Datisi.	VALID.	Undistributed. Middle.	VALID.	*Undistributed. Middle.*
Und. Und. Dis. Und. Und. Und.	I A I. Disamis. Dimaris.	*Undistributed. Middle.*	Undistributed. Middle.	VALID.	VALID.
Dis. Und. Dis. Dis. Dis. Dis.	A E E. Camestres. Camenes.	*Illicit. Major.*	VALID.	*Illicit. Major.*	VALID.
Dis. Und. Dis. Dis. Und. Dis.	A E O.	*Illicit. Major.*	VALID (but useless).	*Illicit. Major.*	VALID (but useless).
Dis. Und. Und. Dis. Und. Dis.	A O O. Baroko.	*Illicit. Major.*	VALID.	*Illicit. Major.*	*Undistributed. Middle.*
Dis. Dis. Dis. Und. Dis. Dis.	E A E. Celarent. Cesare.	VALID.	VALID.	*Illicit. Major.*	*Illicit. Minor.*
Dis. Dis. Dis. Und. Und. Dis.	E A O. Fesapo. Felapton.	VALID (but useless).	VALID (but useless).	VALID.	VALID.
Und. Dis. Dis. Und. Und. Dis.	E I O. Ferio. Festino. Feriso. Fresison.	VALID.	VALID.	VALID.	VALID.
Und. Dis. Dis. Und. Und. Dis.	O A O. Bokardo.	Undistributed. Middle.	Illicit. Major.	VALID.	*Illicit. Major.*

the first figure excludes AEE, AEO, and AOO; the second, OAO; the third, AEE, AEO, and AOO; the fourth, OAO. (3) In consequence of an illicit process in the minor term, the third figure excludes IAA and EAE; the fourth, AAA and EAE. The first figure disregards AAI and EAO, which, though valid, supply conclusions easily attainable, by subalternation from AAA and EAE. The second figure discards EAO and AEO because they are only weakened forms of AEE, and EAE, and follow from these by subalternation. The fourth dismisses AEO because it can get the conclusion by subalternation from AEE. These useless combinations are called subaltern moods. As we had 11 moods capable of being arranged in 4 figures, we have altogether 44 possible moods. Of these, 20 were excluded because yielding fallacious results, and 5 are discarded as useless. If from 44 we subtract 25 there is left, as before stated, a total of nineteen moods. These are—

1st Figure. AAA, AII, EAE, and EIO.
2nd " AEE, AOO, EAE, and EIO.
3rd " AAI, AII, EAO, EIO, IAI, and OAO.
4th " AAI. AEE, EAO, EIO, and IAI.

In the olden days, when books were scarce, dear, and clumsy, scholars required, much more than we do, to make their memory a library, and to condense into the utmost compactness suggestive *compendia* of knowledge. Hence the ingenuity exercised at these distant dates to transmute science into formal representative signs, and to embalm in verse epitomes of learning rendered available for easy use, for guidance, and for certainty. In accordance with their wont, and the urgent necessities of the times, the worthy logicians of the mediæval schools devised the following mnemonic lines, which occur in the *Summulæ Logicales* of Peter Hispanus (Pope John XXI., died 1277). They consist of a number of barbarous words, in which the *vowels* correspond to the different moods in each of the figures, as given in the foregoing list:—

Fig. 1, B*a*rb*a*r*a*, C*e*l*a*r*e*nt, D*a*r*ii*, F*e*r*io*-**que prioris**= of the first.
Fig. 2, C*e*s*a*r*e*, C*a*m*e*str*e*s, F*e*st*i*n*o*, B*a*r*o*k*o*, **secundæ**=the second.
Fig. 3, {**Tertia**, D*a*r*a*pt*i*, D*i*s*a*m*i*s, D*a*t*i*s*i*, F*e*l*a*pt*o*n=the third.
{B*o*k*a*rd*o*, F*e*r*i*s*o*, **habet: quarta insuper addit**=has: the fourth thereunto adds.
Fig. 4, Br*a*m*a*nt*i*p, C*a*m*e*n*e*s, D*i*m*a*r*i*s, F*e*s*a*p*o*, Fr*e*s*i*s*o*n.

CONCRETE EXAMPLES OF VALID AND USEFUL SYLLOGISMS IN EACH OF THE FOUR FIGURES.

	First Figure.	Second Figure.	Third Figure.	Fourth Figure.
A A A	All *imperfect* things perish. All men are *imperfect*. All men perish.	[Would yield an undistributed middle.]	[Would result in an illicit minor.]	[Would result in an illicit minor.]
A A I	[Valid, but useless, because having a *particular*, while the premisses warrant an *immoral* conclusion.]	[Would yield an undistributed middle.]	(All) shame regarding one's birth, rank, or profession has been called modesty. All such shame is really a symptom of pride. Some real symptoms of pride have been represented as modesty.	All wise men love just government. All wise men love well-protected liberty. Those who love well-protected liberty love just government.
A E E	[Results in an illicit major.]	[Would yield an undistributed middle.]	[Results in an illicit major.]	[Results in an undistributed middle.]
A I I	Every manifestation of pride is sinful. Some things approved by the majority of men are manifestations of pride. Some things approved by the majority of men are sinful.	Every material thing is subject to decay. No spiritual being is subject to decay. No spiritual being is a material thing.	All flowers are beautiful. Some flowers are roses. Some roses are beautiful.	All miracles are *violations of the laws of Nature*. *No violations of Nature's laws* are easily credited. Nothing easily credited is a miracle.
A O O	[Results in an illicit major.]	Every true patriot should be honest. Some popular politicians are not honest. Some popular politicians are not true patriots.	[Results in an illicit major.]	[Results in an undistributed middle.]
E A E	*Those who are always in fear* are not happy. Covetous men are *always in fear*. Covetous men are not happy.	No affectation commands respect. All polite demeanour commands respect. No affectation is polite demeanour.	[Results in an illicit minor.]	[Results in an illicit minor.]
E A O	[Valid, but useless, because yielding a conclusion narrower than the premisses warrant.]	[Valid, but useless, because yielding a narrower conclusion than the premisses warrant.]	No man of good character will jest at truth. Some wits do jest at truth. Some wits are not men of good character.	No immoral acts are *lawful amusements*. *All lawful amusements* are sources of enjoyment. Some sources of enjoyment are not immoral acts.
E I O	*Nothing that is hurtful* is desirable. Some pleasures are *hurtful*. There are some pleasures not desirable.	No man of sound sense decries classical studies. Some modern *littérateurs* decry classical studies. Some modern *littérateurs* are not men of sound sense.	No one given to the use of slander is a true patriot. Some men given to the use of slander are politicians. Some politicians are not true patriots.	No true patriot is given to the use of slander. Some persons given to the use of slander are politicians. Some politicians are not true patriots.
I A I	[Results in an undistributed middle.]	[Results in an undistributed major.]	Some men are wise (beings). Every man is an imperfect (being). Some imperfect beings are wise.	Some religious men are deeply imbued with prejudice. All who are deeply imbued with prejudice are unsafe advisers. Some religious men are unsafe advisers.
O A O	[Results in an undistributed middle.]	[Results in an illicit major.]	Some offenders are not conscience-stricken. All offenders have done wrong. Some who have done wrong are not conscience-stricken.	[Results in an illicit major.]

To these lines, which have been slightly altered since their first appearance, there were added other two lines, which are somewhat more than mnemonic :—

Quinque *Subalterni* totidem generalibus orti,
Nomen habent nullum, nec si bene colleges, usum.

(And five Subalterns which, from as many universals, we deduce,
They have no (given) name, nor, if well thou reflectest, use.)

The words marked by distinguishing type, as **prioris**, **secundæ**, &c., which we have translated on the margin, indicate the order or number of the figures to which the moods belong, and serve to make up the Latin hexameters of which the verses consist. The other words with Italicized vowels in them, as *Barbara*, *Celarent*, &c., are mere artificial combinations of letters, in which the vowels represent the moods, A A A, E A E, &c., previously set before the student. The addition of the consonants, however, so as to form a resemblance of words, with the rhythm of hexameter verses, not only enables the learner the better to commit them to memory, but some of them serve also other very useful purposes, which we shall explain when we turn our reader's attention to the method of *reducing* moods from one figure to another.

Meanwhile we shall state some special rules governing the

nature and consequently the arrangement of the proposition of the particular figures :—

Fig. 1, (i.) The major premiss must be universal.
(ii.) The minor premiss must be affirmative.
Fig. 2, (i.) The major premiss must be universal.
(ii.) One or other premiss must be negative.
(iii.) The conclusion must be negative.
Fig. 3, (i.) The minor premiss must be affirmative.
(ii.) The conclusion must be particular.
Fig. 4, (i.) When the major premiss is affirmative, the minor must be universal.
(ii.) When the minor premiss is affirmative, the conclusion must be particular.
(iii.) In negative moods, the major premiss must be universal.

The applicability of these rules to the syllogistic forms of the several figures may readily be examined and tested by the student, and to aid him in this, as well as to enable him to have a distinct conception of the usual and valid syllogism, we set before him a Table of Valid Categorical Syllogisms. The table has been arranged, it will be noticed, alphabetically. This has been done to facilitate reference. By its aid any syllogism whose figure is known may be readily found. If a type-form is given in the table corresponding to that sought, its validity and the grounds of it will at once be seen; and if there is no type-form given, the reason why such a form is inadmissible will be seen and understood.

The student who carefully studies the foregoing tabular forms will readily observe that the first figure alone yields conclusions in all the four forms A, E, I, and O; the second only those in E and O; the third only in I and O, and the fourth in E, I, and O. He will also notice that a *universal affirmative* conclusion, A, can only be deduced in one single mood (*barbara*), of the first figure; that a *universal negative*, E, can be gained from the first, second, and fourth figures in four moods (*Celarent*, *Cesare*, *Camestres*, and *Camenes*); that a *particular affirmative*, I, results in the first, third, and fourth figures in six (*Darii*, *Darapti*, *Disamis*, *Datisi*, *Bramantip*, and *Dimaris*); a *particular negative*, O, can result from syllogisms in all the four figures in the eight moods, *Ferio; Festino, Baroko; Felapton, Bocardo, Feriso; Fesapo, Fresison*. The first figure, inasmuch as it consists in the statement of a general principle, and its application to a particular case, is of the highest scientific value, because it enables us to bring individuals together into species, species into genera, and indeed to form classes of constantly increasing comprehensiveness. The next form of syllogism in value is that which yields universal negatives, and enables the power of discrimination, when duly exercised, to exclude, on special grounds, certain classes (higher or lower) one from the other, and so impart a distinctly definite accuracy to our views in regard to them. Particular affirmatives, while they enable thought to advance a positive step towards the application of a principle, do not avail us to bring the thought it involves directly and by itself to special individual cases.

Particular negatives are of the lowest possible value. Yet particular conclusions possess a distinct use in scientific reasoning. They are very potent in preventing the undue haste with which many investigators claim acceptance for new and wide (if not even false) generalizations. A universal conclusion presented for the acceptance of the mind is shown to be misleading and invalid, by proving a particular negative, and so establishing a contradictory opposite, and a rash universal negative may be efficiently enough exhibited as unduly made when a particular affirmative can be presented in opposition to its relevancy. The logical student will find it an interesting exercise, involving valuable results in his own culture, to examine the foregoing tables carefully, and endeavour to collect and classify the moods which can only yield, (1) affirmative conclusions—of which there are seven; (2) negative conclusions—if one premiss is negative—twelve; (3) particular conclusions—if one premiss is particular—ten; (4) sometimes universal—if both premisses are universal—five; and (5) sometimes particular—four. It will be beneficial too to arrange these according to the figures in which they are valid, and to think out the reasons for their syllogistic validity.

J. H. Lambert, in his "Novum Organon," 1763, gives the following concise statement of the special uses of the several figures:—"The first figure is suited to the discovery or proof of the properties of a thing; the second, to the discovery or proof of the distinctions between things; the third, to the discovery or proof of instances and exceptions; the fourth, to the discovery or exclusion of the different species of genera."

CHEMISTRY.—CHAPTER XII.

MOLECULAR STRUCTURE OF CARBON COMPOUNDS—ISOMERIC COMPOUNDS—MODE OF COMBINATION OF CARBON RADICALS —EXAMPLES.

THE illustrations of molecular structure have, so far, been taken from the class of compounds known in chemistry as acids, bases, and salts; the element carbon, however, exhibits a far greater number of compounds than all the other elements. As a rule they consist of very few chemical elements, chiefly hydrogen, oxygen, and nitrogen, but the number of atoms united in a single molecule is frequently very large, sometimes exceeding one hundred. The number of elements which enter into the composition of organic compounds being so restricted, it is evident that the immense variety of qualities which they present cannot be referred solely to the influence of the simple radicals which they contain, as in the complex compounds of carbon wholly different substances are found having exactly the same composition and the same vapour density. Thus, butyric acid is an oily liquid, the offensive smell of which is perceived in rancid butter, and though it slowly volatilizes at the ordinary temperature, it does not boil lower than 156° C.; it has also the qualities of an acid, reddening litmus paper, and causing an effervescence with alkaline carbonates. Perfectly distinct from butyric acid is acetic ether, a limpid liquid having an agreeable fruity smell, highly volatile, and boiling at 74° C., and without in the least affecting the colour of vegetable dyes. Yet both butyric acid and acetic ether are compounds of carbon, having the same composition and the same vapour density, and in both cases the same formula ($C_4H_8O_2$); therefore the molecules of these two substances contain the same number of atoms of carbon, hydrogen, and oxygen.

ANALYSIS OF ISOMERIC COMPOUNDS.

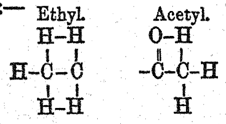
Butyric Acid.		Acetic Ether.	
Carbon, ...	54·51	Carbon, ...	54·47
Hydrogen, . . .	9·26	Hydrogen, . . .	9·67
Oxygen, ...	36·23	Oxygen, ...	35·86
	100·00		100·00
Specific gravity, .	44·3	Specific gravity, .	44·1
Molecular weight, .	88·0	Molecular weight, .	88·0

Modern chemistry has demonstrated that though the fetid smell of rancid butter and the pleasant odour of apples come from substances consisting of elements united in the same proportion, the difference of qualities depends entirely on molecular structure, because the same atoms arranged in a different order may form molecules of different substances, having entirely different qualities; and further, that these *isomeric compounds*, as they are termed, when acted on by chemical agents, break up in very different ways, the resulting reactions showing that certain groups of atoms or compound radicals are present in the compounds, because they are known to exist in the products which these compounds respectively yield. Thus, if acetic ether is acted on by potassic hydrate, the two products are potassic acetate and common alcohol. Alcohol, it is known, has the symbol C_2H_5–O–H, and contains the radical C_2H_5, which is termed *ethyl*. Potassic acetate has the symbol K–O–(C_2H_3O), and contains the radical C_2H_3O, which is termed *acetyl*. Therefore, by inference, the acetic ether contains both of these groups, and its symbol must be C_2H_5–O–C_2H_3O The reaction obtained with potassic hydrate is then a simple metathesis between K and C_2H_5.

$$\left.\begin{array}{c}\text{Acetic Ether.}\\ C_2H_5\text{–O–}C_2H_3O\\ \text{Potassic Hydrate.}\\ \text{K–O–H}\end{array}\right\} = \left\{\begin{array}{c}\text{Potassic Acetate.}\\ \text{K–O–}C_2H_3O\\ \text{Alcohol.}\\ C_2H_5\text{–O–H}\end{array}\right.$$

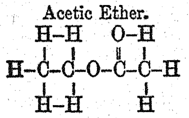
Again, the radical *ethyl* C_2H_5 can be shown to be formed in a compound which contains the radical CH_3, termed *methyl.* Similarly the composition of the molecule of acetyl may be worked out, thus:—

Ethyl. Acetyl.



from which it is inferred that the structure of a molecule of acetic ether should be represented by

Acetic Ether.

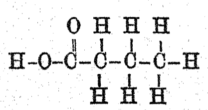


If the isomer of acetic ether, butyric acid, is acted upon with potassic hydrate, the same reagent as before, totally different products are obtained, *potassic butyrate* and *water.*

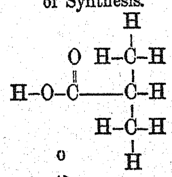
$$\left.\begin{array}{c}\text{Butyric Acid.}\\ H{-}O{-}C_4H_7O\\ \text{Potassic Hydrate.}\\ K{-}O{-}H\end{array}\right\}=\left\{\begin{array}{c}\text{Potassic Butyrate.}\\ K{-}O{-}C_4H_7O\\ \text{Water.}\\ H{-}O{-}H\end{array}\right.$$

Butyric acid, instead therefore of containing the two radicals C_2H_5 and C_2H_3O, like acetic ether, contains a more complex radical, C_4H_7O, and the simple radical H. Very remarkable results have been developed in determining the grouping of the atoms in this radical, as it appears that there are two different radicals having the same composition and corresponding to two distinct varieties of butyric acid, which differ in their odour, their boiling point, and general properties, and various reactions have determined that the atoms of the radicals are arranged in the two acids after the manner indicated in the subjoined graphic symbols:—

Normal Butyric Acid prepared from Butter.



Isobutyric Acid a product of Synthesis.



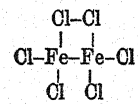
Consequently there are at least three substances having the composition $C_4H_8O_2$. By examining the carbon compounds in a similar manner, and connecting by reactions the more complex with the simpler, the grouping of the atoms in the molecules has been determined in a large number of instances, and the variations of structure which determine the difference of qualities in these isomeric bodies. In many cases it has been found possible to *reproduce* the compounds, and this has led to the discovery of several new bodies isomeric with old compounds. This is very important, as it substantiates greatly the modern theory of molecular structure.

The special characteristic of carbon, on which the intricacy and variety of its compounds depend, is the power which its atoms possess of combining among themselves to an almost unlimited extent. As a general rule chemical combination takes place readily only between dissimilar atoms, although there are many examples of the union of similar atoms, as in the molecules of several of the elementary gases:—

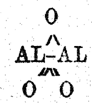
Hydrogen Gas.	Chlorine Gas.	Oxygen Gas.	Nitrogen Gas.
H—H	Cl—Cl	O=O	N=N,

and also in the compounds

Ferric Chloride.



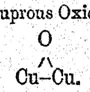
Aluminic Oxide.



Mercurous Chloride.

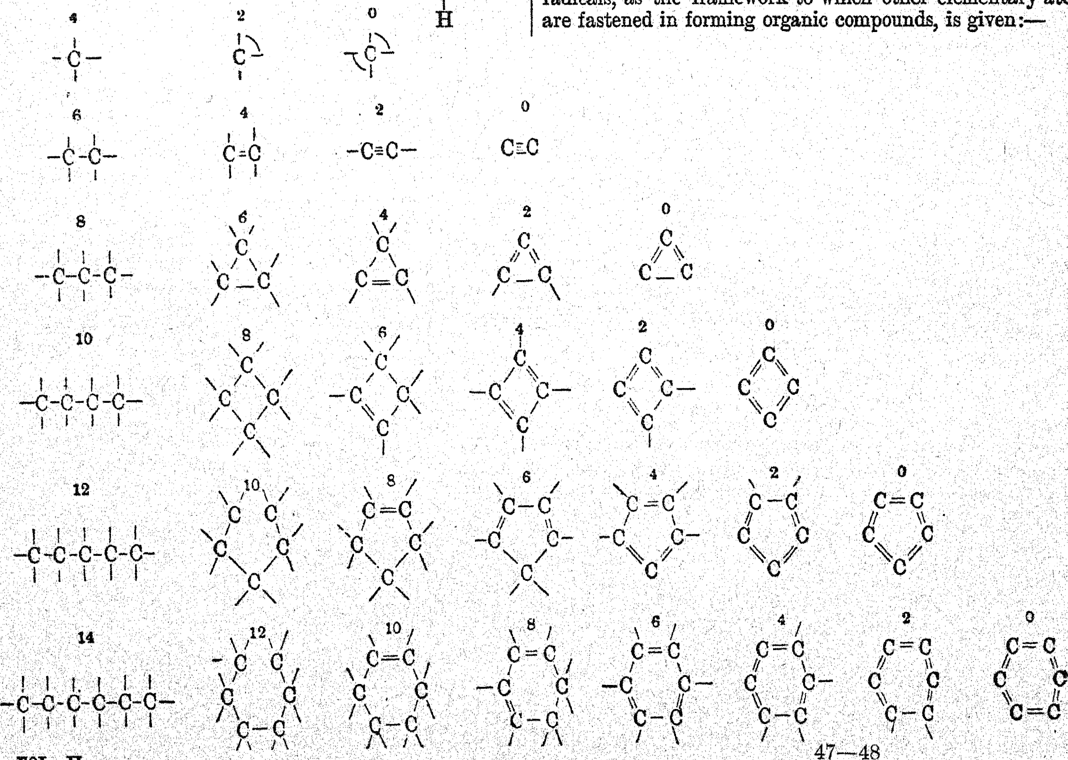
Cl–Hg–Hg–Cl, and

Cuprous Oxide.



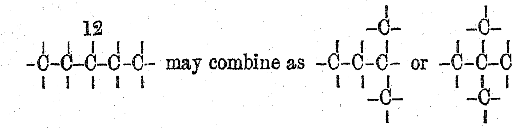
But in all these instances the power of combination is very limited, admitting the grouping together of only a very few atoms, and generally of only two. With the carbon atoms it is different, for not only do they unite with each other in large numbers, but they form groups of great stability, which in *organic compounds* take the place of the elementary radicals of the mineral kingdom.

The carbon radicals form such an important element in the atomic system that an indication of the way in which the atoms may combine, and the inexhaustible combinations producible with a given number of carbon atoms, to form radicals, as the framework to which other elementary atoms are fastened in forming organic compounds, is given:—

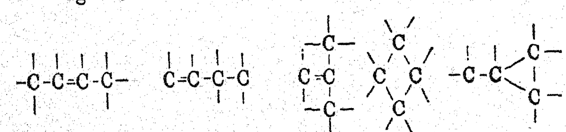


As the carbon atoms are quadrivalent, they may unite with each other by one, two, three, or four poles or bonds, and the larger the number of poles closed the smaller will be the combining power of the resulting radical, as shown by the foregoing diagram. Each group of carbon atoms can have a maximum quantivalence of $2n+2$, where n represents the number of carbon atoms in the group, and from this maximum the quantivalence may fall off by two poles at a time until it is reduced to zero. Thus the group of six atoms may have a maximum of 14, or the same group may have a quantivalence of 12, 10, 8, 6, 4, or 2. Any one of these groups in the diagram may be differently combined by changing the relative positions of the atoms while retaining the same quantivalence. Thus

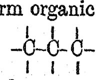
No. 1. No. 2. No. 3.



and although the several radicals thus obtained contain the same number of atoms and have the same quantivalence, they are yet fundamentally different. This difference consists, not in the mere grouping of the symbol, which is purely arbitrary, but in the circumstance, that while in No. 1 no carbon atom is united with more than two others, in No. 2 one of the atoms is united with three others, and in No. 3 with four others. As the number of atoms in the radical increases, the number of possible variations becomes largely augmented. Again, when some of the atoms are united by double poles or bonds, a variation is obtained by shifting the position of this double bond, as well as by changing the position of the atoms with respect to each other. This is shown by reference to the diagram.



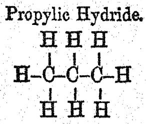
These arrangements may be varied almost indefinitely, the quantivalence remaining unchanged.

These complex molecular structures of solid carbon atoms serve as the radicals with which the three elementary gases, oxygen, hydrogen and nitrogen, are associated to form organic compounds. Thus, taking the carbon radical  it will be seen what a multitude of organic compounds may be formed by the union of different elementary atoms and compound radicals, as:—

Hydrogen.	Oxygen.	Hydroxyl.	Amidogen.	Nitryl.
H–	–O–	H–O–	$\genfrac{}{}{0pt}{}{H}{H}{>}N-$	$\genfrac{}{}{0pt}{}{O}{O}{\gg}N-$

By satisfying all the open poles with hydrogen atoms the radical becomes

Propylic Hydride.

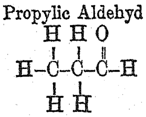


which is a combustible gas found mixed with many other compounds of a similar class in mineral oils, and is the third in a series of nine homologous compounds which have been identified in certain petroleums:—

Methylic hydride,	CH_4		Gas.
Ethylic hydride,	C_2H_6		"
Propylic hydride,	C_3H_8		"
Butylic hydride,	C_4H_{10}	32° C.	boiling point.
Amylic hydride,	C_5H_{12}	86°	"
Hexylic hydride,	C_6H_{14}	142°	"
Heptylic hydride,	C_7H_{16}	194°	"
Octylic hydride,	C_8H_{18}	247°	"
Nonylic hydride,	C_9H_{20}	303°	"

Common kerosene is a mixture of hexylic and heptylic hydride, and light naphthas of amylic and hexylic hydrides. In this series of compounds of hydrocarbons, the change is by the addition of the constant increment CH_2. Again, by substituting an atom of oxygen for two of the hydrogen atoms, the symbol becomes

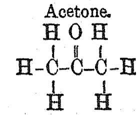
Propylic Aldehyd



a member of another series of carbon compounds parallel to the former. The aldehydes have very striking and characteristic qualities, which may, to a great extent, be traced to their peculiar molecular structure.

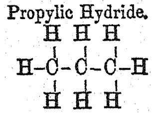
A very slight change in the oxygen atom from the terminal to the central atom of the carbon radical gives rise to a class of compounds which, though isomeric with the aldehydes, have entirely different qualities, and are termed *ketones*. The ketone isomeric with propylic aldehyde is termed *acetone*.

Acetone.

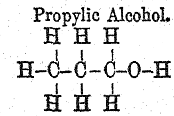


Again, if either of the terminal hydrogen atoms in the hydrocarbon compound C_3H_8 be replaced by the radical hydroxyl (–O–H), a very important class of compounds is obtained, termed *alcohols*.

Propylic Hydride.



Propylic Alcohol.



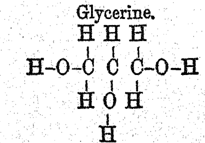
Propylic alcohol is the third member of another series of homologous compounds, of which common alcohol is the second member.

Alcohols.	
Methylic alcohol (wood spirit),	CH_2 –O–H
Ethylic alcohol,	C_2H_5 –O–H
Propylic alcohol,	C_3H_7 –O–H
Butylic alcohol,	C_4H_9 –O–H
Amylic alcohol (fusel oil),	C_5H_{11}–O–H
Hexylic alcohol,	C_6H_{13}–O–H
Heptylic alcohol,	C_7H_{15}–O–H
Octylic alcohol,	C_8H_{17}–O–H

The structure of the alcohols may be varied by transferring the hydroxyl from the terminal to one of the central atoms of the carbon radical, and a new set of carbon compounds is obtained. The acids and alcohols so far formed round the three-atom carbon radicals, have all been monatomic. If, however, two or three hydroxyl groups (–O–H) are attached to the carbon radical, diatomic and triatomic compounds result.

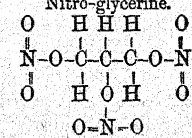
Thus, by attaching three hydroxyl groups, the familiar substance *glycerine* results:—

Glycerine.



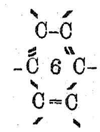
and by replacing the three terminal hydrogen atoms of glycerine by *nitryl* (NO_2), the carbon compound *nitro-glycerine* is produced.

Nitro-glycerine.

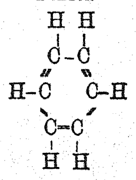


The construction of the molecule of nitro-glycerine points out how the oxygen atoms are separated from the atoms of carbon and hydrogen, for which they have such a strong affinity, and how these atoms rush into more stable combinations when the balance of forces on which the structure is based is disturbed.

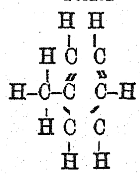
We may take as a final example of carbon compounds the radical which has been exhaustively investigated by Kekuté of Bonn. Among the compounds obtained from it are the aniline dyes, and molecules of extreme complexity may be built up from it either by the addition of hydrocarbon radicals to the nucleus, or by the coalescing of two or more of these nuclei into one. Coal tar is a compound of a large number of substances, the boiling points of which vary from 80° C. upward. On distilling the tar and the distillate rectified, the more volatile product obtained is principally a mixture of two hydrocarbons, *benzol* and *toluol*. This mixture, the benzol of commerce, is employed in large quantities for the preparation of aniline dyes. When benzol and toluol are treated with strong nitric acid the products are:



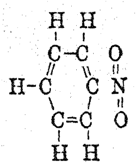
Benzol.



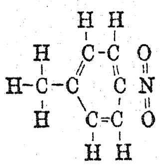
Toluol.



Nitrobenzol.

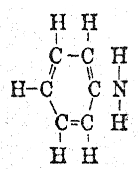


Nitrotoluol.

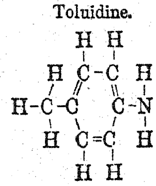


When these compounds are acted upon by nascent hydrogen, obtained from a mixture of iron filings and acetic acid, the products *aniline* and *toluidine* are obtained.

Aniline.

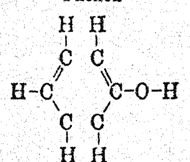


Toluidine.



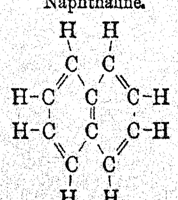
Again, when the compound of aniline and toluidine is treated with certain oxidizing agents, the salts of rosaniline are obtained, which is a base-like ammonia. These salts when crystallized have a very brilliant beetle-like lustre, and yield very beautiful rose-red solutions. Among the less volatile products of the distillation of coal tar is the compound known as *phenol* or *carbolic acid*.

Phenol.

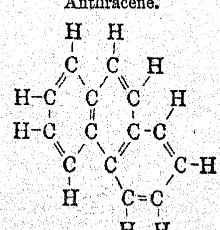


One of the least volatile products obtained in the distillation of coal tar is a hydrocarbon termed *naphthaline*, whose molecule appears to be formed by the coalescing of two molecules of benzol.

Naphthaline.



Anthracene.

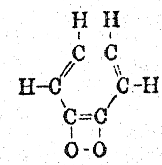


This substance yields a very large number of derivatives having the same general structure, and which are used as dyes. Associated with naphthaline in coal tar is a still less volatile hydrocarbon termed *anthracene*, which may be regarded as formed by the coalescing of three molecules of benzol.

Finally, from anthracene has been derived one of the most important of modern chemical results, *alizarine*. Alizarine is the colouring principle of the madder root, the chief dyestuff used in calico printing. Although, in the process of printing, the mordanted cloth extracts from a decoction of the root the colouring material in a condition of considerable purity, it has nevertheless been found exceedingly difficult to isolate the alizarine. And although the subject has been very carefully investigated, for many years the exact composition of the substance was undetermined.

A German chemist, in investigating a class of compounds whose molecules contained two atoms of oxygen united to a carbon radical in the peculiar manner shown in the typical compound of the class termed *quinones*, incidentally determined the molecular structure of a body closely resembling alizarine, which had been discovered several years previously. This substance was derived from naphthaline, and like many similar derivatives was reduced back to naphthaline when heated with zinc dust. This suggested to the chemist to heat also madder alizarine with zinc dust, when to his astonishment he obtained anthracene; and the inference was at once drawn that alizarine must have the same relation to anthracene that the allied colouring matter bore to naphthaline, and that the same chemical processes which produced the colouring matter from naphthaline when applied to anthracene would produce alizarine. This turned out to be the case, and artificial alizarine, the important madder-dye, is now manufactured on a large scale from the anthracene obtained from coal tar; and this highly complex product has been constructed by following out the indications of its molecular structure, which the study of its reaction and those of allied compounds was able to furnish.

Quinone.



SHORTHAND.—CHAPTER VIII.

EXERCISES IN LEARNER'S STYLE OF PHONOGRAPHY—DISSYLLABIC DIPHTHONGS—S-SHON HOOK.

We have now proceeded so far in our studies of shorthand that the knowledge possessed by the student includes what is known as the "learner's style," and is quite sufficient to enable him to read the exercises that are issued weekly in such periodicals as "The Phonetic Journal," as well as books in this simple style, like Æsop's Fables, &c., published by Mr. Pitman. It goes almost without saying, that reading practice is invaluable. It familiarizes the eye and the mind of the student with the proper consonant outlines, and impresses their form and signification, by repetition, upon the memory. The student is also earnestly recommended frequently to write out a psalm or some simple well-known passages of prose or poetry, and thereafter to transcribe his shorthand into longhand, so as to be able to read readily what he has written. We give now as exercises in the learner's style those three well-known hymns, of which the first lines are:

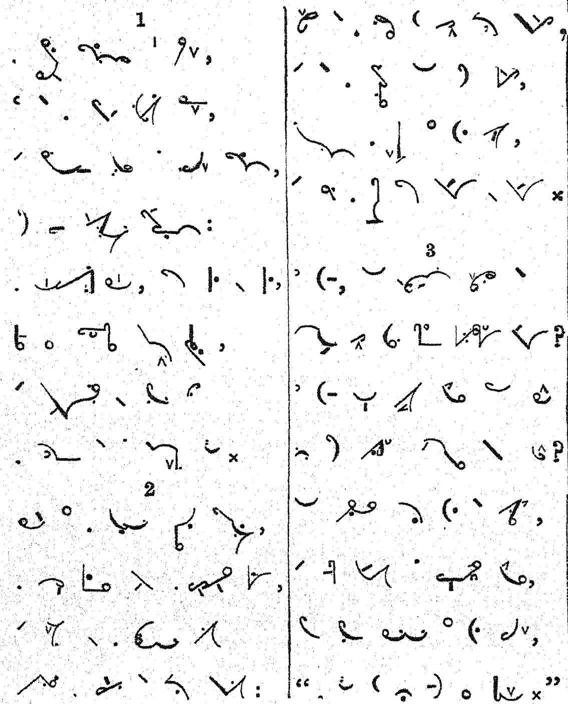
(1) "The spacious firmament on high."
(2) "The Lord my pasture shall prepare."
(3) "When all thy mercies, Oh my God."

We have not thought it necessary to occupy space with the text of these hymns, as they are so well known by most people that they scarcely require reproduction, and they are so easily found in almost any collection of hymns that few, if any, can fail to find a copy readily.

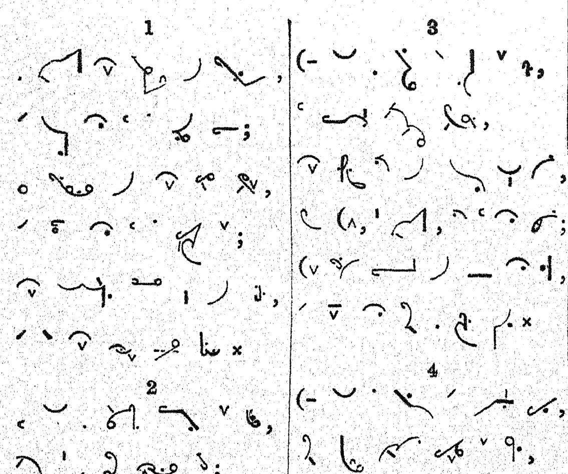
We strongly recommend as good practice for the learner (1) to copy the under-given hymns in shorthand, and to interline them carefully with their longhand equivalents several times, and (2) to write the shorthand on one card and transcribe it in longhand on another, then placing the

one before him reproduce the other, and *vice versa*, taking particular care to make himself, in the process, familiar not only with the outlines, but also with the grammalogues. He would even find it useful to compile upon a small card a concise alphabetical lexicon of the grammalogues, and keep them beside him for reference, repeated reading, and copying out, until they get ingrained in the memory.

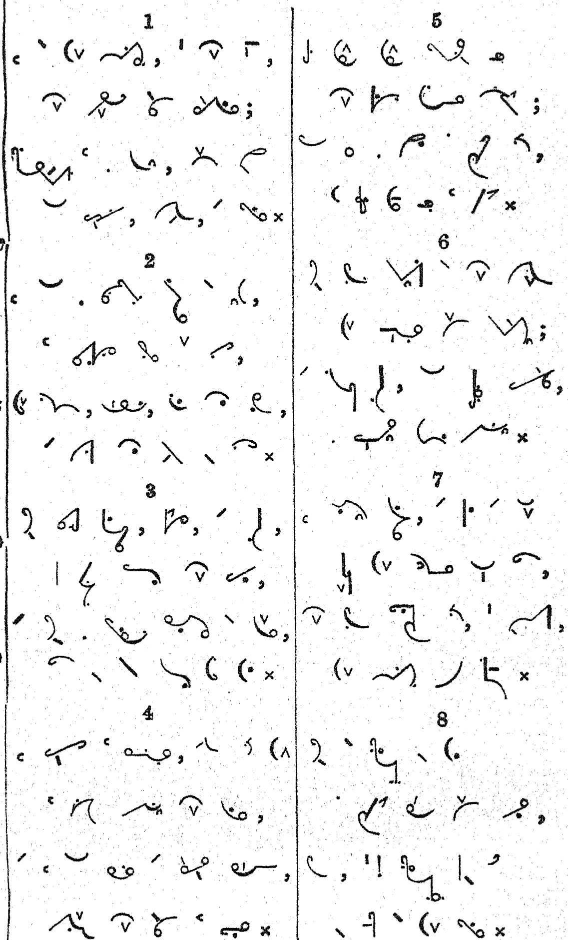
HYMN 1.



HYMN 2.



HYMN 3.



We now proceed to communicate to the student some information regarding the further development of that part of the art of phonographic shorthand which gives a new, fresh, useful, and valuable power to the writer in what is called "the corresponding style." This department of shorthand study includes (1) a further use of abbreviations, (2) the employment of a greater number of grammalogues, and (3) the adoption of a highly advantageous mode of forming two or more words together into one sign, to which has been given the designation "phraseography," *i.e.* phrase-writing.

In our previous lesson we explained the use of the W and Y series of diphthongs. Besides these there are the dissyllabic series of diphthongs. The main difference between these two series is that in the case of the W and Y series it is the second of the amalgamated vowel-sounds which is most distinctly accentuated, while in the dissyllabic series it is the first. The following form the series:—

ah-i, eh-i, ee-i, aw-i, oh-i, oo-i,

This series of signs may represent diphthongs composed of an accented long vowel and any short vowel except ŏŏ. Thus the first may be written alike in *solfaing*, *solfaers*, the second in *saying*, *clayey*, the third in *being*, *real*, *ideal*, the fourth in *sawing*, the fifth in *sowing*, and the sixth in *shoeing*.

There are many words in common use in which these dissyllabic diphthongs present themselves as orthographic requirements. The student may write out the following words in which they occur:—Aërated, bayonet, layer, theory, museum, panacea, drawing, lower, knowing. Many other words involving the same diphthongal elements will readily

suggest themselves to the memory, and by careful attention to the forms of writing those given above, accuracy and speed in the writing of the dissyllabic diphthongs required in such words will readily be acquired.

S-SHON HOOK.

We may now extend the information formerly communicated when we explained the use of the *shon* hook (p.559). This hook may not only be employed in the way already described, but it can also be used after the circle *s* or the syllable *ens*, by continuing the *s* circle to the other side of the consonant, thus :— *decision*, *possession*, *position*, *transition*, *compensation*. This same hook may, besides, be vocalized for a second or third place vowel, merely by writing the vowel sign before the end of the outline for a second-place vowel, and after it for a third-place vowel—though really, in practice, it is rarely necessary to a hand and eye familiarized with phonographic writing, as the distinguishing vowel of the primary consonant forms a sufficient index to the word. The circle *s* or *z* may also be added to this back hook, and it may even be occasionally used in the middle of a word, as *positions*, *positional*, *transitional*.

In our next lesson we shall proceed to treat of the management of prefixes and affixes, and to set before the student other principles useful in abbreviating the signs of frequently recurring words. Meanwhile the student should read carefully the simple forms of shorthand to be found in the printed phonography to which we have referred, and write as much of it out as he can find time and opportunity to do, especially attending to the double transcribing which we have already urged upon him, so that he may become thoroughly familiar with the consonants, the outlines, the syllabic combinations, the terminal forms, and the grammalogues.

MUSIC.—CHAPTER VIII.

INTERVALS—TABLE OF INTERVALS AND THEIR INVERSIONS—MODULATIONS—TRANSITIONS—ORNAMENTAL NOTES—EXERCISES AND ILLUSTRATIONS.

THERE are in music, as in every other science and art, various technical details which seem (and often are) of small importance in practical work—so far, at least, as elementary studies are concerned—but which, from their position in what may be called the literature of the subject, imperatively demand the attention of every careful, exact, and intelligent student. Thus a complete theoretical knowledge of *interval* is not, perhaps, absolutely necessary to the learner who only wishes to acquire the power of reading music with ease and facility, or singing-at-sight, as it is termed; for, as in this course, he may have been taught to strike with his voice the different tones more from an appreciation of their effect on his mind than from an intimate acquaintance with their mathematical relations. For those who wish to undergo public examinations, however, and for purposes of harmony, as will be seen hereafter, it is necessary that careful study should now be made of their names, appearance, and functions.

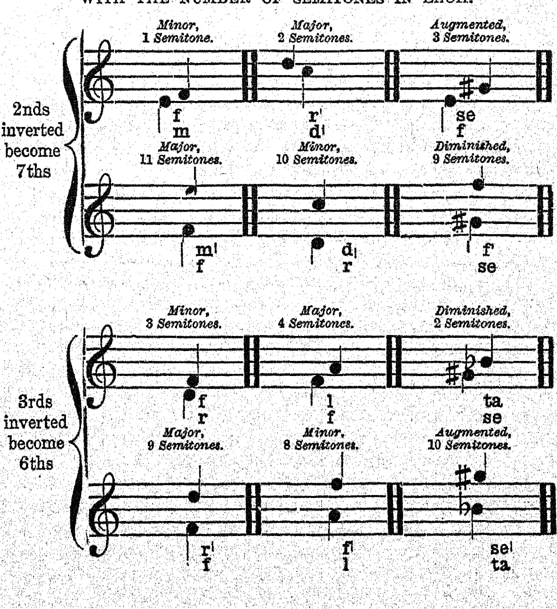
As already explained (p. 175), an interval in music means the difference in pitch or distance between one tone and any other. In reckoning intervals we count from the lowest to the highest, and both extremes are included. Thus, from Doh to Ray is a second or one degree, Doh to Me is a third or two degrees, Doh to Fah a fourth, Doh to Soh a fifth, Doh to Lah a sixth, Doh to Te a seventh, and Doh to Doh' an eighth or octave. The different degrees of the scale not being exactly alike (p. 753), it follows that the interval, say between Ray and Fah, will, although it has the same number of degrees, be different from that between Doh and Me; hence another designation is required for it.

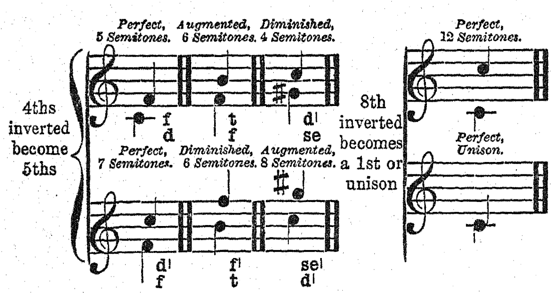
Intervals are of five kinds, viz. (1) major, (2) minor, (3) augmented, (4) diminished, and (5) perfect. (1) A major interval contains one semitone more than a minor interval of the same name. Thus from Doh to Ray is a major second, containing or made up of two semitones; from Me to Fah is a minor second, containing only one. Doh to Me is a major third, containing two full tones (Doh to Ray and Ray to Me) or four semitones. Soh to Te and Fah to Lah are also major thirds. Conversely, (2) a minor interval contains one semitone less than a major of the same name. Lah to Doh', Ray to Fah, Me to Soh, and Te to Ray are minor thirds, each having one whole tone and one semitone, or three semitones in all. (3) An augmented interval, as was seen in Chapter IV., contains one semitone more than a major interval of the same name. Thus Fah to Se (F to G♯) is an augmented second containing three semitones, while a major second has only two. It will be seen from this that an augmented second has the same number of semitones as a minor third, but it must never be written as a third. Thirds must always appear as thirds, seconds as seconds, and fourths as fourths, &c., whatever may be the number of semitones they contain. To do otherwise would be to alter entirely the character of the intervals, and to give them another name. (4) A diminished interval contains one semitone less than a minor, as from Se (the sharp of Soh) to Ta (the flat of Te, or G♯ to B♭) is a diminished third containing only two semitones. (5) Perfect intervals are so called because they cannot be made less or more without becoming either diminished or augmented. The perfect intervals are the fourth, fifth, octave, and unison. Strictly speaking the unison, *i.e.* two or more sounds equal in pitch, is not an interval, but a combination, and as such comes under the term "perfect." The inversion of an interval is simply a turning of the notes of which it consists upside down. When this process has been gone through major intervals become minor, minor become major, augmented become diminished, and diminished become augmented. Thus from Doh' to Me' (C to E) is a major third, while from Me to Doh' (E to C) is a minor sixth; from Te to Doh' (B to C) is a minor second, while from Doh to Te (C to B) is a major seventh; from Fah to Se (F to G♯), as already stated, is an augmented second; from Se to Fah (G♯ to F) is a diminished seventh.

Perfect intervals although inverted remain perfect, thus a perfect fifth, as Doh to Soh (C to G), becomes a perfect fourth, as Soh to Doh' (G to C), and *vice versa*. An octave becomes a unison, and a unison an octave. It will help the memory if it is observed that in every case an interval and its inversion make the number nine. In the following table each lower staff gives the inversion of the notes which appear in the upper with which it is bracketed. Conversely each upper is the inversion of each lower staff. Let it be observed that the number of semitones contained in any interval added to the number contained in its inversion make twelve.

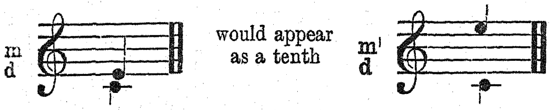
TABLE OF INTERVALS AND THEIR INVERSIONS,

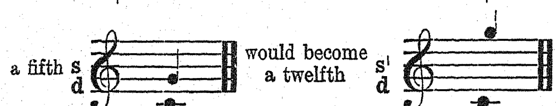
WITH THE NUMBER OF SEMITONES IN EACH.

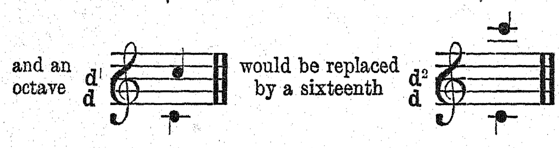




Replication of an interval implies that the upper note has been raised an octave higher, or that the lowest note has been placed an octave lower. Thus a replicated third, as



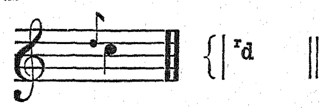




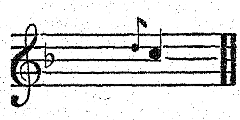
It is not, however, found necessary, in practical work, to rename these widened intervals. A tenth is still, therefore, looked upon and spoken of as a third, a twelfth as a fifth, a sixteenth as an octave, &c.

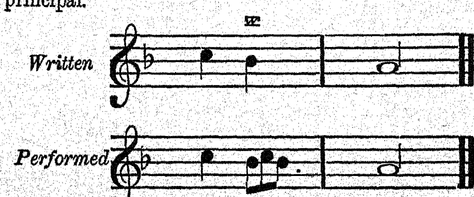
The transitions and modulations with which the student has now become acquainted must, as will readily be understood, have greatly enlarged the resources of the modern musician, and have put into his hands a power of giving variety and of adding interest and beauty to his work to an extent of which early writers had not the slighest conception. In Exercises 101 and 102 (p. 755), it was shown that tunes and pieces begun in the minor mode very frequently passed, for a time, into the major, when Doh assumed all its original importance. This is called a Modulation to the relative major. When, on the contrary, a tune or lengthened piece begins in the major and passes to its Lah or minor mode, it is said to modulate into its relative minor. The one mode, or way of using the scale, is thus said to be the relative of the other; and in modulating to and from these modes some of the finest and most tender musical effects are produced. Mr. Curwen and other writers hold that a *modulation*, or change of mode, should be considered as distinct from a *transition*, which means a change of key, but it may be well here to say that a change of mode is, in reality, a change of key also; for while the minor mode continues, Lah discharges all the functions of a key-tone, imparting, by means of its minor third—Lah to Doh (A to C)—and minor sixth—Lah to Fah (A to F)—all its own mournful character to the music. The word "modulation" is therefore frequently used in this double sense, *i.e.*, it may either mean (1) a change of mode, as above, or (2) an entire change of key—a transition. The practice, however, of giving a definite name to each separate thing has many and obvious advantages. *Modulation* will therefore be held in this work to mean the change from major to minor, or *vice versa;* and *transition*, the passing from one key to another. The tune "Balfron" (p. 855) modulates to its relative minor towards the close of its second line or section; while the use of Fe (E♮) in the bass at the close of the third section causes a brief transition into the first sharp key. In the tune "Kinross" (p. 856) this order is reversed. The transition to the first sharp key occurs at the close of the second section, and the modulation to the relative minor at the end of the third. The latter is the course of transition and modulation most frequently chosen by composers. In ordinary tunes, or short pieces, transition to the first flat key seldom occurs, except in a very transient or "passing" form, (as in the first section of "Kinross"), till towards the end of the composition. Flat key-transition has, in general, a saddening depressing effect on the music, and returning to the original key after a short excursion into this dull region, enables the composer to finish his piece with all the brilliance of a first sharp transition. So do light and shadow act and react upon each other, and mutually assist in imparting pleasure to the beholder as he looks on the finished painting. Proceeding still further in the same direction, it has been found that a modulation to the relative minor of the first sharp or first flat keys, can often be made with great ease and with excellent effect. The relative minor of the first flat key is much more frequently used in this way than its first sharp neighbour. It does not seem to the ear so far removed from the original key, nor has it the "wild and sad" sound that the latter produces. This modulation is often used for a period so very brief, that in the sol-fa notation it is most frequently written in a disguised form, and not according to the "better method" (see p. 656). Just as (Fe the sharpened or raised Fah) is often to be looked upon as in reality a new Te, and Ta (the flattened Te) is felt to be a new Fah, so De (the sharpened Doh) is in truth the leading note Se to the new Lah. In illustration of this, see the third section of the tune "Govan" (p. 856). In like manner, when the music passes to the relative minor of the first sharp key, and the original Me becomes Lah or the key-tone, the new leading note often appears as Re—the sharpened Ray. In the fourth section of the tune "Spohr" (given in page 857). this change occurs, and continues so long that the bridge-tones are used in Sol-fa, and the notes appear in their true character. Here, as will be seen, the music passes at once from A♭ major, into the relative minor of E♭ (C minor). This is called a "transitional modulation," *i.e.* there is at the same time a change of key and a change of mode.

Ornamental notes used in vocal music are chiefly of five kinds, viz.—(1) the *appoggiatura* or leaning note, which until recent times was always written as a small note before its principal, as—



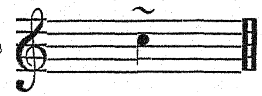
It has in each case the value in time of the note written, which time must be taken from the full-sized note which succeeds it. Modern writers nearly always write it out in full.

(2) The *acciacatura* (literally, crushed or crushing note) is intended to be sung as short and sharp as possible, and the accent falls on the principal note. It is distinguished from the appoggiatura by a thin hair line drawn across its stem and hook thus:—

Sometimes what may be called a double acciaccatura occurs, when the note below as well as the note above is treated in the manner described. In this, as in the other case, the accent falls on the principal note.

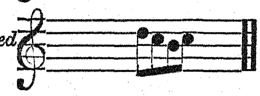
(3) The *mordent*, generally shown by this sign 𝆕, indicates that the principal note and the note above it are to be sung as rapidly as possible, the voice returning at once to the principal.

The *inverted mordent* shows that the principal note and the note below it are to be sung as above. In sol-fa the notes are usually printed as they are to be performed.

(4) The *turn* (~) consists of a group of four notes, being the note above or higher than that over which the turn is placed, the principal note itself, the note below (generally only half a tone), and again the principal note, thus:—

Written

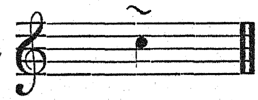


Performed

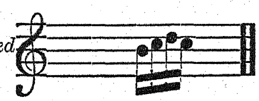


If it is desired to sharpen or flatten either of the unwritten notes the necessary sign is placed above or below to indicate the same. The sign for the fully written example mentioned would be ~♯. The inverted turn shows that the performer is to begin with the note below instead of that above, thus:—

Written



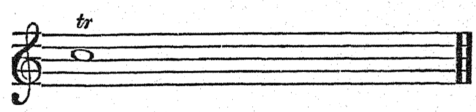
Performed

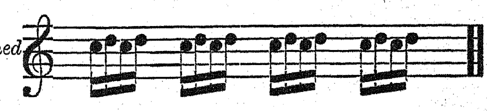


(5) The *shake*.—This ornament requires, for its effective use, long and careful training, and perhaps, owing to the time and care it requires, is not used in vocal music nearly so much as it once was. It consists of the rapid and regular alternation of two notes either a tone or a semitone apart. To produce it properly the throat must be freely open, and the vocal apparatus thoroughly under control. The sign for the shake is *tr.*

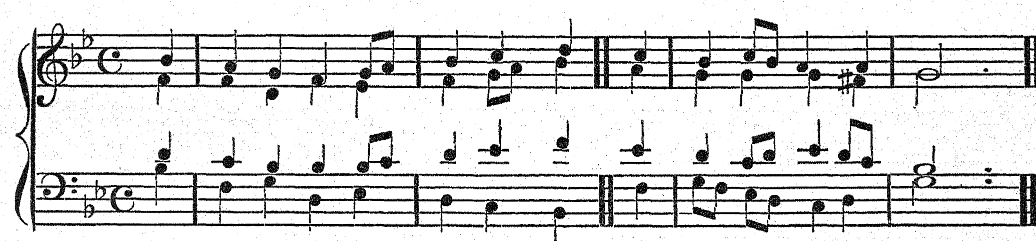
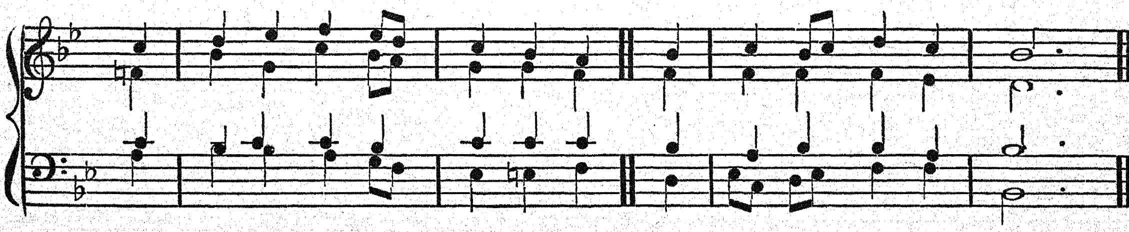
SHAKE, WITH A FULL TONE BETWEEN THE NOTES.

Written

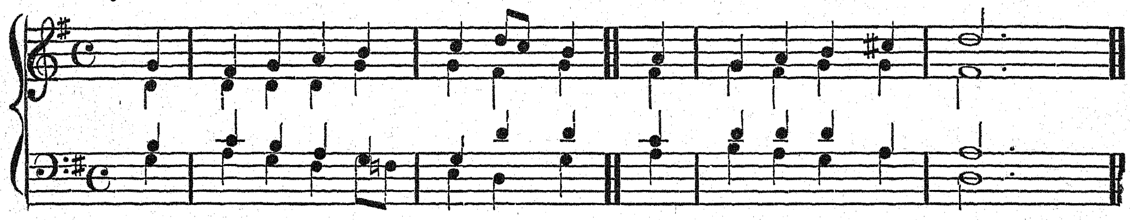


Performed

The speed of the notes in the shake may be doubled, so that instead of sixteen notes to the semibreve, as above, the performer may give thirty-two. If the notes B and C (Te and Doh) were used there would be a shake with the notes a semitone apart. Sometimes the shake finishes with a turn, and occasionally its upper or under notes are inflected by a sharp or flat.

Key B♭ **Exercise 103.**—TUNE, "BALFRON," C.M. J. Sneddon, Mus.Bac.

Sop.
Alto
Tenor
Bass

:d	t_1 :l_1	s_1 :l_1.t_1	d :r	m ‖	r	d :r.d	t_1 :t_1	l_1 :—	—
:s_1	s_1 :m_1	s_1 :f_1	s_1 :l_1.t_1	d ‖	t_1	l_1 :l_1	l_1 :se_1	l_1 :—	—
:m	r :d	d :d.r	m :f	s ‖	f	m :r.m	f :m.r	d :—	—
:d	s_1 :l_1	m_1 :f_1	m_1 :r_1	d_1 ‖	s_1	l_1.s_1 :f_1.m_1	r_1 :m_1	l_1 :—	—
Oh	with thy	ten - der	mer - cies,	Lord,	Us	ear - ly	sat - is -	fy,	

:r	m :f	s :f .m	r :d	t_1 ‖	d	r :d .r	m :r	d :—	—
:s_1	d :l_1	r :d .t_1	l_1 :l_1	s_1 ‖	s_1	s_1 :s_1	s_1 :f_1	m_1 :—	—
:r	d :r	r :d	r :r	r ‖	d	t_1 :d	d :t_1	d_1 :—	—
:t_1	d :d	t_1 :l_1 .s_1	f_1 :fe_1	s_1 ‖	m_1	f_1 .r :m_1. f_1	s_1 :s_1	d_1 :—	—
So	we re -	joice shall	all our	days,	And	still be	glad in	Thee.	

Key G. **Exercise 104.**—TUNE, "KINROSS," C.M. JAS. SNEDDON, Mus. Bac.



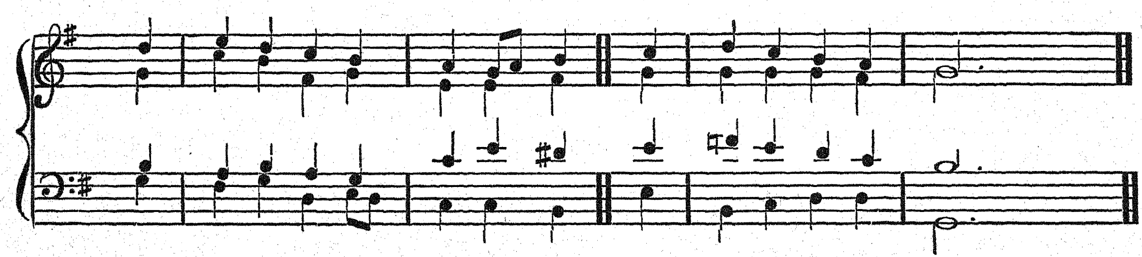
:d | t, :d | r :m | f :s.f | m || r | d :r | m :fe | s :— | — ||

:s, | s, :s, | s, :d | d :t, | d || t, | d :t, | d :d | t, :— | — ||

:m | f :m | r :d | d :s | s || f | s :s | s :r | r :— | — ||

:d | r :d | t, :d.ta | l, :s, | d || r | m :r | d :r | s, :— | — ||

I of the Lord my God will say, He is my re - fuge still,



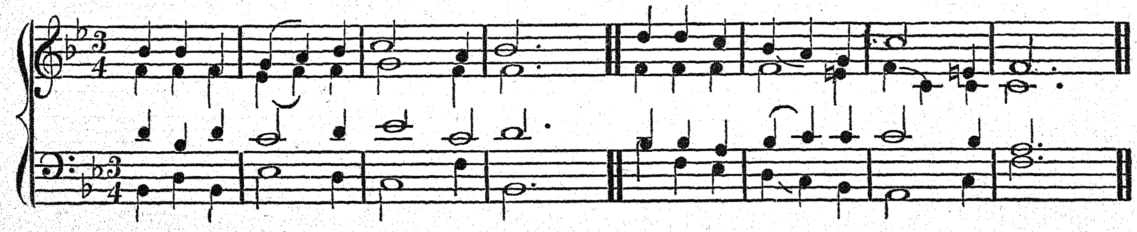
:s | l :s | f :m | r :d.r | m || f | s :f | m :r | d :— | — ||

:d | f :m | t, :d | l, :l, | t, || d | d :d | d :t, | d :— | — ||

:m | r :m | r :d | f :l | se || l | ta :l | s :f | m :— | — ||

:d | t, :d | s, :l,.s, | f, :f, | m, || l, | m, :f, | s, :s, | d, :— | — ||

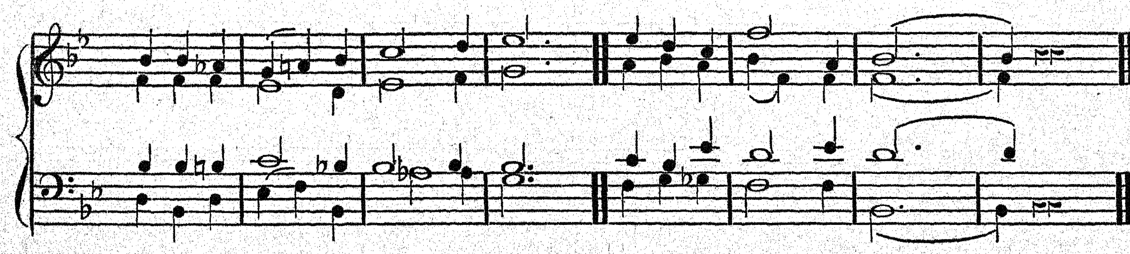
He is my fort - ress and my rock, And in Him trust I will.

Key B♭ **Exercise 105.**—TUNE, "GOVAN," 888 6. JAS. SNEDDON, Mus. Bac.

| d :d :s, | l, :t, :d | r :— :t, | d :— :— || m :m :r | d :t, :l, | r :— :fe, | s, :— :— ||

| s, :s, :s, | f, :s, :s, | l, :— :s, | s, :— :— || s, :s, :s, | s, :— :fe, | s, :r, :r, | r, :— :— ||

| m :d :m | r :— :m | f :— :r | m :— :— || d :d :t, | d :r :r | r :— :d | t, :— :— ||

| d, :m, :d, | f, :— :m, | r, :— :s, | d, :— :— || d :s, :f, | m, :r, :d, | t_2 :— :r, | s, :— :— ||

Just as I am, with-out one plea, But that thy blood was shed for me,

| d :d :ta, | l, :t, :d | r :— :m | f :— :— || f :m :r | s :— :t, | d :— :— | — : : ||

| s, :s, :s, | f, :— :m, | f, :— :s, | l, :— :— || t, :d :t, | d :s, :s, | s, :— :— | — : : ||

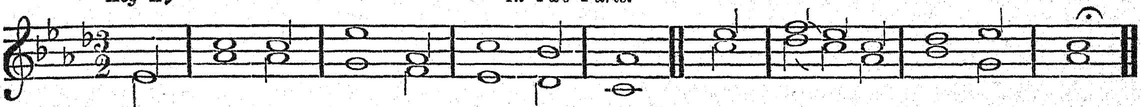
| d :d :de | r :— :d | d :— :d | d :— :— || r :d :f | m :— :f | m, :— :— | — : : ||

| m, :d, :m, | f, :s, :d, | ta, :— :ta, | l, :— :— || s, :l, :la | s, :— :s, | d, :— :— | — : : ||

And that thou bidst me come to thee. O Lamb of God, I come.

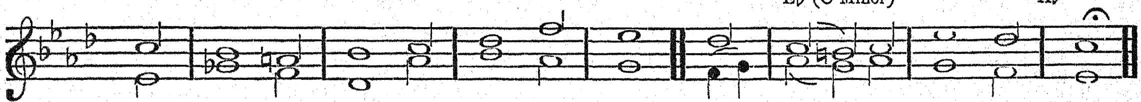
Exercise 106.—TUNE, "SPOHR," 86 86 86. *From* SPOHR.
Arranged by J. S.

Key A♭ *In Two Parts.*

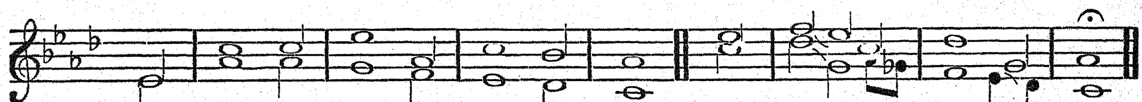


{:s_1 |m :— :m |s :— :d |m :— :r |d :— ||s |l :s :m |f :— :s |m :—
{:s_1 |d :— :d |t_1 :— :l_1 |s_1 :— :f_1 |m_1 :— ||m |f :m :d |r :— :t_1 |d :—

O Christ, what bur - dens bow'd thy head, Our load was laid on Thee.

E♭ (C Minor) A♭

{:m |r :— :de |r :— :m |f :— :l |s :— ||f |ml :se :l |d' :— :t |ˡm :— ||
{:s_1 |ta_1:— :l_1 |f_1 :— :d |r :— :d |t_1 :— ||l_1 .t_1 |ᵈf :m :f |m :— :r |ᵈs_1 :— ||

Thou stood - est in the sin - ner's stead, Didst bear all ill for me.



{:s_1 |m :— :m |s :— :d |m :— :r |d ||s |l :s :m |f :— :t_1 |d :— ||
{:s_1 |d :— :d |t_1 :— :l_1 |s_1 :— :f_1 |m_1 :— ||m |f :t_1 :d.ta_1 |l_1 :— :s_1.f_1 |m_1:— ||

A vic - tim led, Thy blood was shed, Now there's no load for me.

DRAWING.—CHAPTER VII.

DECORATIVE OR CONSTRUCTIVE DRAWING.—PART I.

IN our introductory chapter we stated that all drawing was divided into two great branches, which might be respectively designated (1) *imitative*, and (2) *decorative* or *constructive.* Our instructions have hitherto been confined to the former of these divisions, and we have endeavoured to show the student how he may acquire that skill of hand which will enable him to depict in various ways the images or appearances which natural objects present to the observant eye. By these means forms of beauty may be multiplied and preserved. Any one, therefore, who has acquired this aptitude, and has become a proficient in imitating the forms of Nature, may reasonably consider that he has attained a desirable accomplishment and power. But looked at in another way all this skill and knowledge is only a means to an end—not at all an end itself. These are the means by which we store the mind with beautiful forms, and enable the imagination to arrange and combine these forms, and apply these combinations to some practical purpose, such as the ornamentation of a vase or the decoration of a wall.

This art is called designing or constructive drawing. It has been practised by all nations, among the most ignorant savages as well as among the refined and learned Greeks; and in all periods, from those of the mysterious epochs of the "first stone age" down to the nineteenth century. By far the greatest part of the art-work now existing in the world is of this "decorative" kind. All the wonderful work which fills us with astonishment and admiration on the great buildings of our own and other countries, the sculpture on the stately Parthenon or the Gothic cathedral, the frets, the scrolls, and mouldings of classic art, the flowers, foliage, and quaint forms of mediæval times, all come under the head of ornament or decoration. The products of art with which we store our museums, and by means of which we hope and expect to educate and elevate the people, are for the most part decorative works. Unfortunately this work, as it lies in our museums, is but little understood, and its educational influence will not be thoroughly effective until it is more fully explained by means of suitable lectures, popular pamphlets, and those more elaborate descriptions which may direct attention, form opinion, and stimulate emulation. Of ten people who would admire and find pleasure in a realistic picture, probably not more than one would admire the beauty of a vase or a piece of foliated scroll-work. Yet this realistic picture-painting is quite a modern outcome of reproductive art; and all the art of all the ages before was of quite a different character, and had quite a different aim. It was executed for the purpose of decorating or making more beautiful certain definite buildings or objects. All this vast mass of art-work may be roughly classified and divided into two

Fig. 1.

sorts—viz. (1) "figure," and (2) "ornament," although the two are almost inextricably interblended; the figure being constantly used for decorative purposes, and ornament being constantly mixed with, and partly composed of, figures. See fig. 1.

Taken altogether, the subject is too extensive to be dealt

with fully in our brief space, and we shall therefore omit any detailed consideration of the figure and confine ourselves to ornament.

The character of this ornament has varied immensely in different ages and countries, and the study of these variations or "styles" of ornament is most instructive to the art-student and most interesting to the general reader. Their differences are distinct and evident, yet it has been found that in them all certain common principles exist which underlie the construction of all ornament and pervade all decorative art.

Not only do we find these principles in Art, but we find the same or similar ones in Nature; thus proving that all good art-work is founded upon Nature and follows Nature's laws. This indeed is universally considered to be a test of good ornament. If it violates the laws of Nature it is held to be base and degraded work; if it be in accordance with those laws it is regarded as true "fine art."

A careful analysis of ornament will also show that it consists very largely in the combinations of certain simple elementary forms. These simple forms are generally geometric, and we come to the conclusion that ornamental art is based upon, or constructed by means of, geometry.

We hear much in these days about technical and artistic education. It is advocated, with many variations of phrase, on all hands. The supremacy, even the very existence, of our manufacturing industries is said to depend upon the securing of a great development of this art-education; and the question of how this education is to be most easily and effectively imparted is really one of the most important questions of the day.

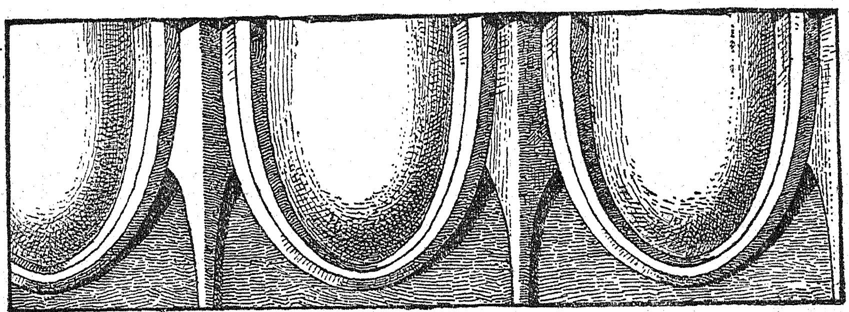
The exhibition of works of art in museums, the copying of ornamental forms in schools, are helpful, it is true, but these means are not sufficient; we should not expect to teach literature by simply turning students into a library; work, if it is to be rightly studied for reproductive purposes, must be analyzed, its principles taught, and its mode and functions explained.

We propose to point out a course of study which will not only be useful to the industrial artist, but interesting and instructive to all who are students of art, such as will enable each of them the better to appreciate decorative art-work, and to bring true art and the creations of taste into their own homes by constructing decorative forms which may be applied in various ways.

The fundamental principles or laws of ornament are as follows :—

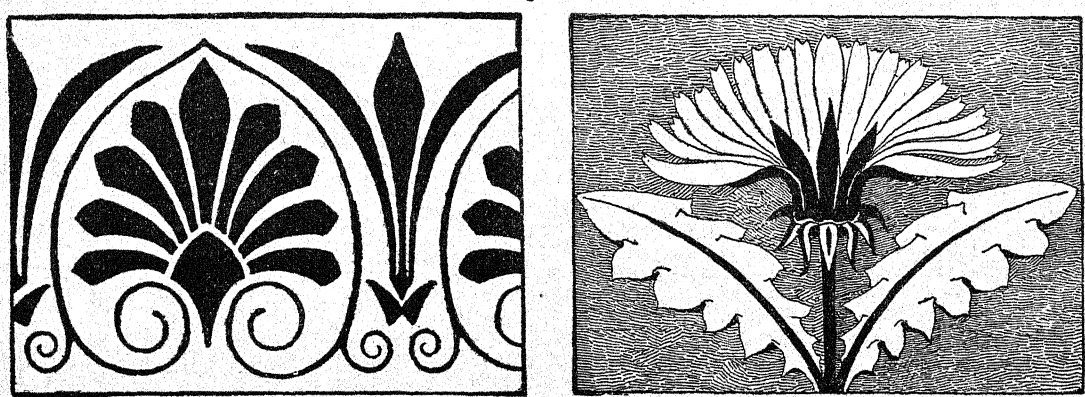
(1) *The Equal or Even Distribution of Parts.*—This principle is perhaps more universally displayed in the art of all ages than any other. It is perhaps most obvious in diapers and similar flat decorations, but it may be found in all good ornament, even when that ornament consists partly of figures. It may also be observed in great buildings and in good pictures. "Even distribution," therefore, does not necessarily mean a perfectly uniform net-work of exactly similar spaces; but that there shall be a perfect and subtle harmony between the decorative forms, the spaces which they occupy, and the ground upon which they are placed; that no part shall be crowded while another part is left bare or weak; that minute detail shall not be mixed indiscriminately with bold forms, but that there shall be an appropriate and satisfactory agreement or harmony between the dimensions of the ornamental parts as well as attractive grace in their exhibitions of form.

Fig. 2.



(2) *Repetition.*—This will be found to be an important feature of plant-form as well as of ornamental art, again showing that all good art is founded on natural laws. A reference to our chapter on "Flowers and Foliage" (p. 565) will show that repetition is the order of growth in nature, and hundreds of examples might readily be pointed out of its practice in art. Many of the well-known Greek borders, for instance, consist of the simplest elementary forms repeated again and again (see fig. 2); indeed the more simple the form, the more suitable it is for repetition. One can look with pleasure upon this "egg-and-tongue" ornament repeated indefinitely, but a head or a figure repeated without variation soon becomes wearisome and distressing. In fabrics and wall papers repetition is invaluable, the repeated forms being most frequently simple or composite geometric figures.

Fig. 3.

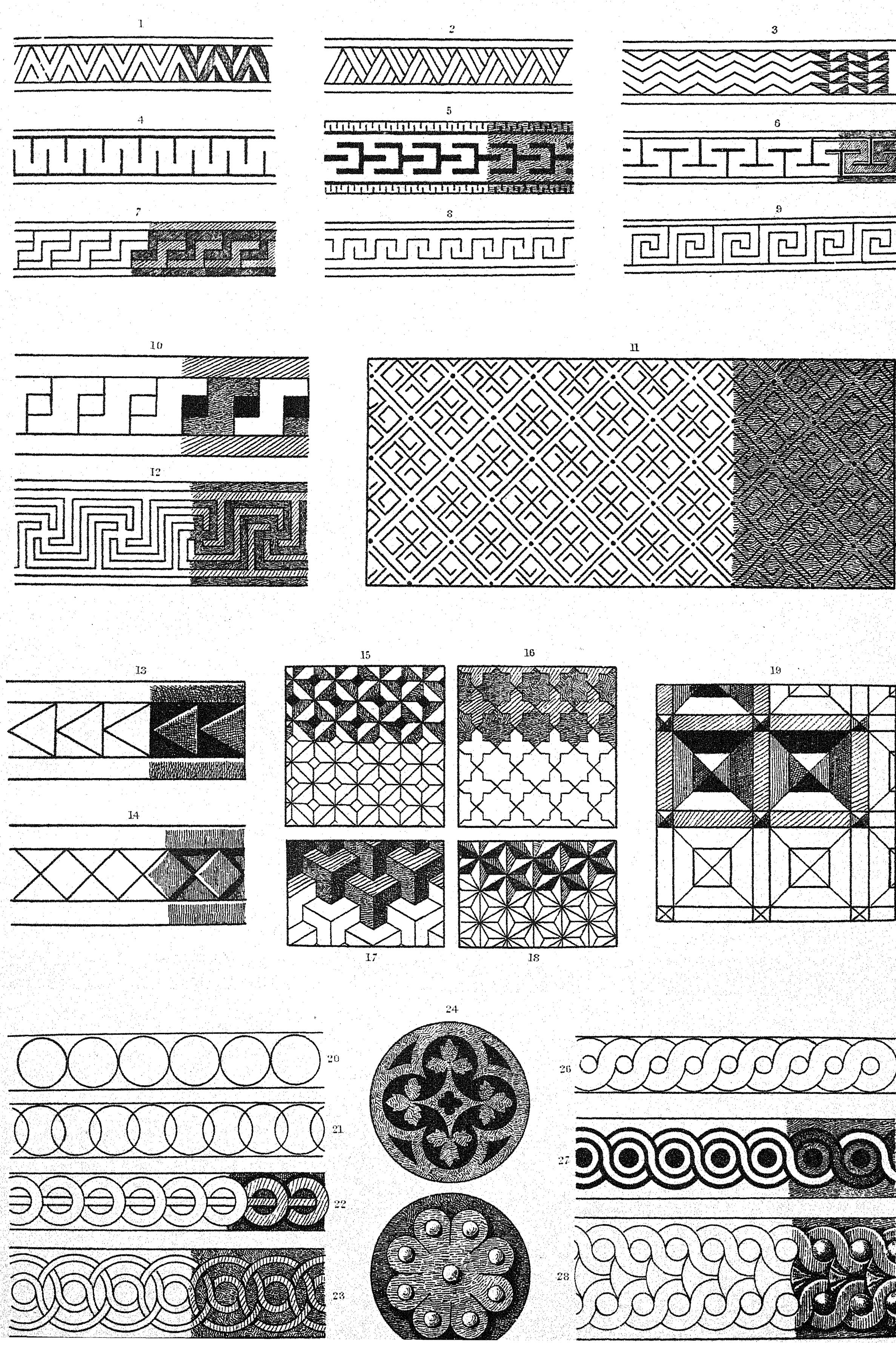


(3) *Alternation* is a modification of repetition, and is also common to nature and art; in flowers it is almost an invariable law, the petals being alternated with the sepals, &c. This alternation in ornament prevents the monotony which might spring from repetition. In the egg-and-tongue moulding we find that the large oviform masses are alternated with the sharp tongues or arrow heads (fig. 2).

(4) *Contrast or Variety.*—This principle is partly explained in the preceding paragraph, and may be illustrated by the same figure. By bringing together two opposite qualities or forms, such as an oval and an arrow head, a circle and a

DRAWING.

DECORATIVE OR CONSTRUCTIVE.



square, it is not only possible to avoid monotony, but to obtain vivacity, brilliance, and force.

(5) *Radiation.*—The repetition of forms in such a manner as to give the idea of growth from a certain point, as in the Greek anthemion or the star-like petals of a flower, is another important ornamental principle (fig. 3).

(6) *Symmetry* is perhaps the most difficult to define of all these principles, and yet it is one of the most important. It is displayed in the great divisions of a temple or cathedral as well as in the least important ornament with which such buildings may be decorated. It is a specific form of repetition, and is most easily attained by merely doubling or repeating twice; for, strangely enough, almost any form—even though it may not be beautiful in itself—may when balanced by repetition become symmetrical and ornamental. This law of symmetry is most obvious in classic work. In Gothic art we get greater variety, which is in itself too a law of ornamental art, but one of lower rank than of symmetry. Variety produces that which is picturesque and irregular, symmetry that which is simple, dignified, and orderly.

These are some of the great principles which govern the construction of all good ornament. Without them ornament would be inorganic, petty, and valueless. There is in the human mind a mysterious demand for law and order, and even in the matter of decoration this demand must be satisfied. The most playful and fanciful curves of the Italian renaissance; the intricate band-work of the painted and gilded walls of the Saracenic mosque; the stern, rugged sculpture of the Gothic cathedral, must all seem to be governed by principles and subordinated to laws, or else the mind rejects them as flacid, meaningless, and ineffective.

We now turn to the more practical part of our subject, and shall try to show by analysis that ornament is not only governed by principles, but is also (like the world of nature) made up of simple elements or elementary forms. These forms are all geometric. Owen Jones, one of the greatest authorities upon this subject, says, "all ornament should be based upon a geometrical construction." We will therefore take first the simplest and most elementary form—a straight line. One of the most obvious and important uses of the straight line is to bound or hold together the more complicated ornamental arrangement, as in the borders of panels (see fig. 4, part of the façade of the cathedral of Florence), and in the mouldings of classic architecture; the utility of the straight line in this particular can hardly be overstated. Apart from its immense importance in architecture, we shall find that it frequently forms the backbone of decoration, and that a design which might be loose and nerveless by itself, is made firm and compact by the judicious introduction of the right line.

Not only may ornament be bounded and inclosed by means of straight lines but it may even be composed entirely of them; examples of such composition are numerous, and some of these are given in Plate VIII. No. 1 is the well-known zigzag found in the ornamentation used in early ages and among savage tribes. It is astonishing how much variation may be made in the zigzag; some examples are shown at 2 and 3, and the student may readily and profitably exercise his ingenuity and deftness by devising others. The Greeks used the right line in frets or "key borders," examples of which are given at 4, 5, 6, in Plate. The first is formed by single lines, the second by putting lines at right angles, and the third by using the letter T. A few other examples are added to show how the student may multiply these frets or borders almost indefinitely by using combinations of straight lines and by altering the angle at which they are placed. All the right-lined letters of the alphabet, as E, F, H, &c., may be taken as elements, and innumerable borders made by combinations of their forms. Taking three straight lines and forming a triangle, or four, making a square, we have two geometrical forms with which an endless variety of decoration may be constructed. Some examples of these forms and their combinations are given in the Plate. The squares and triangle may be used together. Pieces may be cut out of one side of the squares and added on to the other sides; or passing from mere form we may get an alternation of light and dark by shading one of the forms, as shown in Plate.

Fig. 4.

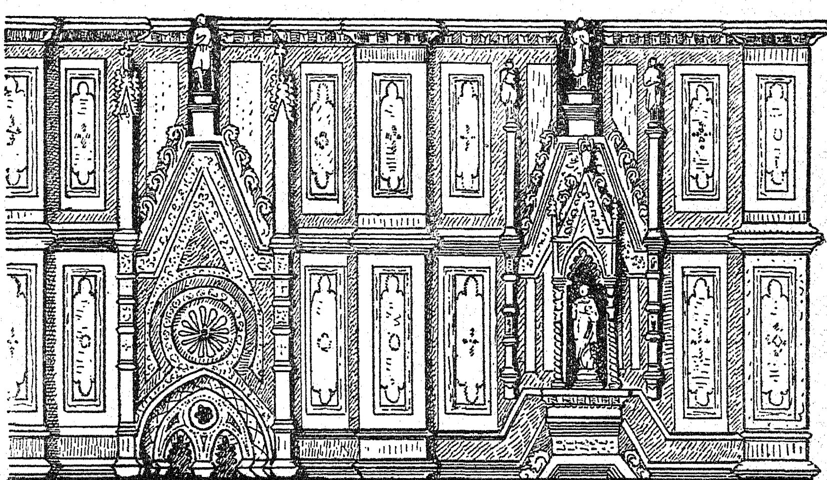
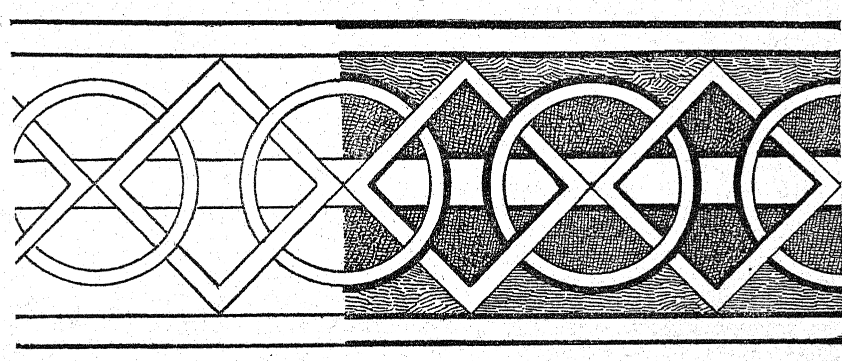


Fig. 5.



A careful study of the examples here given, and of more elaborate ornaments to be found in books (such as Owen Jones' "Grammar of Ornament,") and on such objects of ornamental art as are to be found in museums and elsewhere, will, if the student note them well, show that a vast amount of ornament is, has been, and may be constructed or designed by the combinations and alternations of one or more of these very simple right-lined forms and other similar ones, *e.g.* the pentagon, hexagon, octagon, &c.

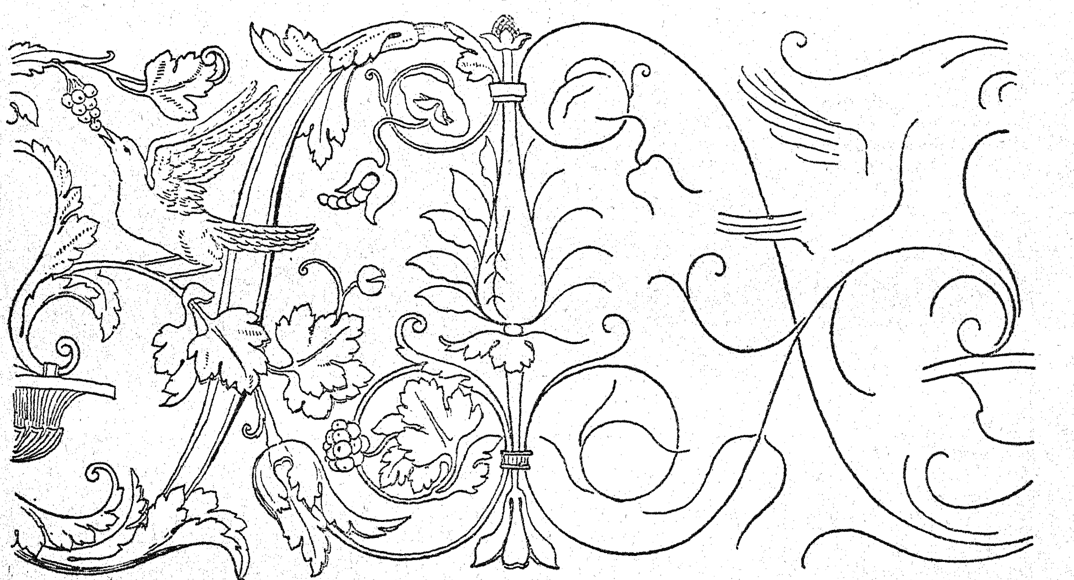
Taking the circle next we shall find it a very important element; the mere repetition of it, as shown at 19 in Plate, forms a most pleasing border, and by overlapping it in various ways (as at 20, 21, 22) a number of similar designs may be made. The well-known guilloche (25, 26, 27) is only a combination of circles.

The alternation and combination of the circle and the square, or of the circle and other right-lined figures, give again an extraordinarily extensive series of ornamental forms. An example is shown at fig. 5. A square with a piece taken out of one side and added on to the other side makes a useful and symmetrical form. This method of dividing or cutting up and adding to a regular geometric form, again introduces a large series of ornamental patterns, which in practice may be indefinitely extended by the patient ingenuity and thoughtful endeavours of any active mind and skilful hand.

The ellipse and the oval are also geometric forms from which the most beautiful and delicate ornamental results may be obtained. The use of elliptical curves in preference to the circumference of the circle is characteristic of the best periods of art; the Greek curves are mostly elliptical, and the forms of ornament used by the great artists of the Italian renaissance are frequently founded upon the ellipse or the oval (fig. 6). The well-known "line of beauty" is an elliptical curve, and with this alone many ornamental forms may be made. It is hardly necessary to say that with these curves and curved forms we enter upon the largest division of conventional ornament, as the more subtle the line the greater is the possibility of extending the series of combinations.

We have hitherto spoken of ornamental designs, which may be constructed entirely by the aid of geometrical forms, omitting altogether the work which consists of, or is based upon, natural forms or outlines adapted from nature. This class of decorative drawing will be treated of in our next chapter; we wish for the present to confine ourselves to geometric design, and to show here the close connection which exists between practical geometry and constructive drawing. The examples which we have given in the figs. have been of the simplest kind; some of a more elaborate sort are given in the Plate, but even these are simple in comparison with others which might easily have been shown. The marvellous and beautiful tracery of the windows and screens during the best period of Gothic architecture is all purely geometrical in its construction, and very wonderful is the analysis of this work, a small portion of which was given in Plate I., and a large number of excellent examples are given in Brandon's "Analysis of Gothic Architecture," and in Billings' "Tracery of Carlisle Cathedral," &c. Actual examples of this tracery may be found in the windows of almost any parish church, and those who live near a cathedral can find many beautiful specimens which may be most profitably studied. The genuine art student should not be content merely to admire, but should endeavour to trace and find out the geometric basis of all these beautiful and intricate lines which result in pleasing products, and not only to formulate their varieties but to imitate them with slight alteration.

Fig. 6.



More wonderful (though not more beautiful) examples of geometric ornament, or the application of geometry to decoration, may be found in other kinds of art work. Very early illuminated manuscripts, such as Celtic (Irish), are full of the most wonderful and elaborate geometric forms, which have evidently been founded upon the simple elementary figures that have been the subject of consideration in this chapter.

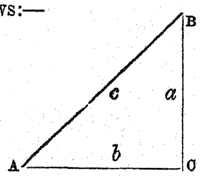
The very beautiful mosaic pavements of the Romans, and the wall decoration of Byzantine and Romanesque architecture, are also largely composed of geometric forms. But perhaps the most attractive historic ornament in which geometry bears an important part is that which is called Saracenic or Moresque. The Mohammedans were forbidden by their religious laws to make images of living things, and one result of this was that they elaborated band-work and geometric forms to a wonderful extent. Almost all the beautiful decoration of the world-famed Alhambra is composed of interlaced patterns of the most complex kind. Without geometry this would result in hopeless and useless confusion; but being based upon the laws and principles of ornament, and constructed by the aid of geometry, the result becomes "a thing of beauty and a joy for ever."

TRIGONOMETRY.—CHAPTER IX.

VERIFICATIONS OF THE METHODS FOR THE SOLUTION OF TRIANGLES.

It was the practice of the late Rev. John Hymers, D.D., one of the most famous and successful of the fellows and tutors of St. John's College, Cambridge, during a quarter of a century, to present to his pupils for practical exercises in trigonometrical calculations the opportunity of verifying the methods of solving questions regarding triangles, by supplying the sides and angles of triangles in the common numerical notation, and their logarithmic equivalents, in order that they might, with the same figures and under the same conditions, work out the solutions with such results as by their mutual consistency should make it quite plain that the principles on which their calculations were founded were firm and sure. Taking a leaf from his book, we shall ask our readers now to test with us, in this practical form, the method of the

solution of right-angled triangles explained in our previous lessons. The figures given are as follows:—



Sides $a = 1540{\cdot}374$ Log. $= 3{\cdot}1876262$
" $b = 902{\cdot}708$ " $= 2{\cdot}9555475$
" $c = 1785{\cdot}395$ " $= 3{\cdot}2517343$

Angle A59° 37′ 42″ } L. sin. 9·9368919; L. cos. 9·7038132; L. tan. 10·2320786

CASE I.—Given hypotenuse c [*i.e.* A B] and angle A, to find the other angle B and the sides a [*i.e.* B C] and b [*i.e.* A C].

First, to find the angle B we say, 90° − 59° 37′ 42″ = 30° 22′ 18″, angle B.

Second, R : sin. A : : A C : C B; and *third*, R : cos. A : : A C : A B.

Sin. A 59° 37′ 42″	=	9·9358919
A B log.	=	3·2517343
Sum,		13·1876262
Radius,		10·0000000
1540·374 B C	=	3·1876262
Cos. A. log.	=	9·7038132
A B "	=	3·2517343
Sum,		12·9555477
Radius,		10·0000000
A C 1785·395	=	2·9555475

CASE II.—Given a side a [*i.e.* B C] and the angle opposite to it, A, to find the other angle B, the side b [*i.e.* A C] and the hypotenuse c [*i.e.* A B].

The angle B has already been found.

R : tan. A : : A C : C B, and R : sec. A : : A C : A B.

[Secant A is found by subtracting the log. cos. from 20.]

Tan. A 59° 37′ 42″ log. − R	= ·2320786
A C "	= 2·9555475
C B = 1540·374	= 3·1876261
Sec. A 59° 37′ 42″ log. − R	= ·2961868
A C "	= 2·9555475
A B 1785·395	= 3·2517343

CASE III.—Given the hypotenuse c [*i.e.* A B] and a side a [*i.e.* B C], to find the remaining side b [*i.e.* A C] and the two angles.

A B : B C : : R : sin A, and R : cos. A : : A B : A C.

B C 1540·374 + R = log.	13·1876262
A B 1785·395 "	3·2517343
L. sin. A = 59° 37′ 42″	9·9358919
Cos. A = log.	9·7038132
A B "	3·2517343
	12·9555475
R −	11·0000000
A C 9020·708 =	2·9555475

[Angle B is found by taking A + B = 90° − 59° 37′ 42″ = 30° 22′ 18″.]

CASE IV.—Given two sides a [*i.e.* B C] and b [*i.e.* A C], to find the hypotenuse c [*i.e.* A B] and the angles.

A C : B C : : R : tan. A, and R : sec. A : : A C : B C.

B C + R = log.	13·1876262
A C = "	2·9555475
Tan. A = 59° 37′ 42″	10·2320787
Sec. A − R = log.	·2991868
A C = "	2·9555475
A B = 1785·395	3·2517343

Put to the test in this manner, and carrying our operations through the entire series of the correlations of sides and angles which geometry has proved and trigonometry assumes, we see that the later application of science to the practical purposes of life and the arts fulfils its function thoroughly; and that its general rules can be trusted in regard to their results through their entire range as far as the solution of right-angled triangles is concerned.

It should be so in the methods it prescribes for the solution of oblique (or obtuse) angled triangles. Of course, it must be remembered that a triangle can only be formed, not with *any* three given sides, but with the given sides so proportioned that "any two sides of a triangle taken together are greater than the third" (Euclid I. 20). As in every triangle "the greater side subtends (*i.e.* is opposite to) the greater angle" (18), and conversely "the greater angle is subtended by the greater side," we have in the case of oblique-angled triangles the condition that the longest side normally constitutes the base, and is the most convenient to work with. It is requisite to keep this in mind, because unless the greatest of the three sides is taken in such triangles one of the segments of the base becoming negative, the half-difference of the two segments becomes greater than the half-base, and cannot be arithmetically subtracted from one another; and we require several alterations to be made in the rules for guidance, which have been duly formulated. It is not impossible to work solutions where a less side is [as indeed sometimes it must be] taken; but it is unadvisable to choose (when choice is given us) a less instead of a greater side.

HISTORY OF GREAT BRITAIN AND IRELAND.

CHAPTER VIII.

WALLACE AND BRUCE—BATTLE OF FALKIRK—SCOTTISH INDEPENDENCE—THE DEATH OF EDWARD I.

Two names are registered in the book of fame as the winners of Scotland's national independence—Sir William Wallace and King Robert Bruce. Legend and poetry have been busy weaving garlands of glory round their memories, and even sober-suited history tells the story of their works and woes with a thrill of emotion and in tones of enthusiasm. We must be brief chroniclers rather of the general results of their efforts than of their achievements—attractive though the theme be.

The father of Wallace was Sir Malcolm Wallace, Knight of Elderslie in Renfrewshire, and his mother a daughter of Sir Reginald Crawford, sheriff of Ayr. Under an uncle, priest of Dunipace, he was prepared for school, to which he went at Dundee—where Blair, his biographer, was his companion. When he grew up he possessed every quality of mind and person for a leader of the people. He was pleasant-featured, broad-shouldered, large-limbed, clear in judgment, eloquent in speech, renowned at once for humanity and courage. He was trusted by the masses, who would not, as the nobles had done, consent to regard Edward's deposition of Balliol as legal, or that sovereign's over-lordship as a thing to be endured. They chafed under the tyranny practised upon them, and they scorned the nobles, who had become Edward's thralls. Wallace and many others chose to incur the risks and the joys of freedom. In various ways, small bands of sympathizers with him formed confederacies against Englishmen, and made many attacks upon them whenever chance arose. The governors increased their exactions and extortions, and the people panted more earnestly for their expulsion. Wallace unfurled the banner of revolt, and round him many rallied, resolved to challenge directly the right of English rule.

Surrey had gone to the English parliament, Ormesby was holding his court at Scone. Wallace by a rapid march surprised the Justiciar, took many prisoners and a rich booty. Only by hasty flight was Ormesby's personal safety secured. This public act proved the prowess of Wallace, and committed him in the eyes of all men as the opponent of England and the defender of Scotland's rights. His compatriots greeted him as "the Guardian of Scotland." Edward was startled. He commanded Surrey to call out the military forces north of the Trent, and that nobleman sent his nephew Henry Percy with 40,000 footmen and 300 horsemen into the West

Country. He defeated the Scots at Lochmaben and Irvine. The nobility succumbed, but Wallace had now effectually roused the whole spirit of the nation. Even the barons connived at their tenantry's taking part in the affrays which took place between English officials and banded companies of insurgents. Edward's energetic impetuosity led him to supersede the dilatory Surrey. He made Brian Fitz Alan Governor of Scotland, yet commanded Surrey to lead his hosts to battle. Wallace, who had successfully stormed almost all the strongholds held by Englishmen north of the Forth, had settled down to besiege the Castle of Dundee when he heard of Surrey's advance against him with an immense army. Commanding the people of Dundee on pain of death to maintain the siege, Wallace hastened to secure the high ground at Cambuskenneth before the English troops crossed Stirling bridge. He succeeded. Surrey had 50,000 foot and 1000 horse. Cressingham, who was in ill-humour with Surrey, ordered the disbandment of 8000 foot and 300 horse brought by Percy, as they had quite enough for anything they had to do. Surrey (11th September, 1297) proffered peace if submission were made. Wallace replied: "We came ready for battle, to avenge wrongs and to maintain rights. We shall reckon with you beard to beard." Cressingham murmured at the expense of delay. "Cross the bridge," said Surrey, and the Lord Treasurer leading the van, with Sir Marmaduke Twenge, passed over. Wallace allowed one half to cross unhindered. He had sent a detachment by a detour to possess the bridge. Seeing that force ready he descended like an avalanche from the hill slopes. The English reeled back; in so doing they threw their comrades into confusion, and terrible havoc ensued. Twenge hacked his way through the Scottish columns across the bridge again, where Surrey stood paralyzed at the slaughter. Hastily ordering Twenge to man Stirling Castle and promising to relieve it in ten days, the leader of that great host spurred off unhaltingly to Berwick and left the soldiery to their foes' hate. Cressingham was slain, his dead body flayed, and Wallace made a sword-belt of part of his skin. The defeat was total and the rout ruinous. All the fortresses were retaken, and Scotland was free from the foot of every foe, save famine. That led the Scots to make desperate forays into the north of England, and these marauding bands laid hands on anything they could get.

Edward, enraged, arranged a truce with Philip, which resulted in the treaty of Chartres (1299) and Edward's marriage with Philip's sister Margaret in 1300. Then hastening home, he marched north to administer personal chastisement to the rebel Scots. He led an army 80,000 strong. Wallace, knowing how effectually starvation diminishes an armed force, scoured the south country, and swept from it provender and provisions. Edward's march was through a desolated land. His force had rendezvoused at Roxburgh, 24th June, 1298; he took Dirleton Castle, where his troops endured great privations, which he shared with them unflinchingly, and advancing to Kirkliston encamped on Linlithgow Moor. Wallace, whose aim was to lead Edward into the trackless woodlands and marshes, where he could attack his troops suddenly and unwarned, had gradually disappeared before him, till despair filled the monarch's mind, and he meditated a retreat towards Leith. Then would have been Wallace's chance; he got ready to pursue and plague. But traitors had betrayed his intention to Edward, and he, though by a kick from a horse he had two ribs broken the night before, marched through Linlithgow, and espied the enemy. The Guardian of Scotland disposed his infantry in four compact *schiltrons* of lancemen and archers; the former kneeling formed a serried circular front, the latter standing within the ranks could ply their arrows as required. Edward's soldierly eye saw at once the dexterity of this disposition, and he warily hesitated. His officers counselled instant action. "In God's name, let it be so then," said he, and the commanders pressed forward. The moment the lines met, the Scottish nobles, who led the heavy-armed cavalry, deserted, and left the infantry to bear the brunt of Edward's onset. It was fierce and effective, and when a body of troops led by Bruce attacked him in the rear, Wallace, seeing defeat was inevitable, drew off his forces to Callander Wood. Carronshore was a wild waste of death. The Scotch retreated from Falkirk to Stirling, and when they found they could not withstand the English there they set it on fire. Four days after the battle of Falkirk, Edward reached the Dominican convent there, and took a fortnight's rest to recover health. He wasted and overran Clydesdale, Ayrshire, and Annandale and having reached Carlisle, proceeded to distribute among his earls and barons large estates and numerous strongholds. At Durham messengers informed him that, having hardly waited for his absence, the Scots were again in arms. He returned to Newcastle, and went thence to Coldingham; but famine and fatigue had wrought grievously on his forces, and he issued a writ for the assembling of a new army to chastise the obstinate and reiterated rebellion of the Scots. Wallace went to Flanders and urged Philip to continue those attempts at pacification between Edward and the Scots which he had begun in the interests of Baliol. Edward, though embroiled with his barons, engaged in negotiations with France. On the eve of his marriage he held a council at Westminster concerning his Scottish expedition, and seven days after the matrimonial ceremony at Canterbury ordered his barons to meet him with men, horses, and arms on 10th November, at York.

The Scottish regents, Comyn, De Soulis, Bruce, and Lamberton of St. Andrews, besought truce; Edward deigned no reply, met his barons at York, and marched to Berwick, but beyond this the nobles would not go. Next year when Edward renewed his campaign, following the tactics of Wallace, the regents avoided battle, hung on the outskirts of the host, made predatory onslaughts, and cut off supplies. Edward took the castles of Lochmaben and Caerlaverock, encamped in Irvine, removed to Dumfries, and after spending five months in Scotland disbanded his army, proclaiming a truce. This cessation of war, though granted on the alleged suggestion of Philip the Fair, was greatly due also to his receiving a command from the Pope, given at the instigation of Wallace and the regents, that he should desist from all hostilities. The Pope, however, accompanied this command with a claim by the Holy See to the superiority of Scotland. This Edward refused to admit. More intent now than ever on the subjugation of Scotland, he made great preparations, provided a fleet of seventy ships, and dividing his army into two parts, placed one under the command of his son and put himself at the head of the other. The campaign was fruitless, but Edward spent Christmas, 1301, in Linlithgow Palace.

Having appointed John de Segrave Governor of Scotland, Edward returned to London. Segrave, accompanied by an army provided by twenty-six of Edward's chief barons, marched from Berwick to Edinburgh. The Scots, who had made a forced march from Biggar to Roslin, opposed him on the way and thrice defeated him, 24th February, 1302. Chafed and enraged, Edward resolved to make a solitude and call it peace: and he did so. Everywhere, his whole armed force being under his own leadership, Edward enforced submission. Wallace, when Scotland was under the oppressor's iron heel and the people were courage-broken, reappeared in the woods and fastnesses round Stirling and about Dunfermline, where the King held state. Fearing that Wallace might make Stirling Castle his headquarters, Edward set out to besiege it. Comyn hastily ordered the bridge to be destroyed. Edward forded the Forth, routed the little army, and Comyn submitted to Edward. The garrison of Stirling still held out. They were outlawed, and Wallace—left alone, exempted by name from all amnesty—quailed for a season and meditated surrender. Edward set a reward of 3000 marks upon his head. Stirling Castle capitulated—Edward's conquest was complete—and he spent Christmas-tide at Lincoln in great glee.

But one man was still unsubdued, and that such a sovereign as Edward should show so much anxiety that he should be taken, and taken in shame and by guile, is perhaps the best proof that could be had of the worth of Wallace. This hero was concerting measures for Scotland's relief, when Sir John Monteith received intimation of his being in Rutherglen, near Glasgow, and through the treachery of a servant made the patriot a prisoner and delivered him to Edward. He was taken to London and brought to trial in Westminster Hall before English judges on a charge of treason. He denied

ever having been under fealty to England's King, and therefore could not be a traitor to him. He was, however, sentenced to be hanged by the neck, cut down and beheaded, disembowelled and his entrails burnt, his head affixed to London Bridge, and his four quarters exhibited in Berwick, Newcastle, Stirling, and Perth. He had reached London in chains on 22nd August, 1305, next day he was tried, and on the next again he was dragged on a hurdle, at the tails of three horses, to a gallows at the Elms, Smithfield, and execution done. Edward drew up a scheme for the government of Scotland; but Bruce hurried to Scotland, interviewed Comyn in Gray-friars Kirk, Dumfries, was charged with perfidy, and slew his cousin Comyn at the altar. Only by making a bold bid for kingly power was there a chance for safety. Bruce was crowned at Scone, 25th March, 1306, and Edward's conquest was worthless. He took an oath to win back Scotland or die in the effort. He had knighted his son Edward and 200 squires in joy at his victory. With this prince and his fellow-knights, Aylmer de Valence, Edward's nephew, set forth with England's forces northwards. Bruce was in Galloway when they entered Scotland. They advanced to Perth. Bruce met them at Methven and was completely defeated. He was derisively spoken of as "the summer king." With a few friends he endured many hardships and was driven to seek refuge in the Western Isles. Hot pursuit of him was made. Almost all the aristocratic powers in Scotland were unfavourable to him, but the people, who had really been roused to national feeling, followed with hope the fugitive Bruce, who though hunted by Highlanders and chased by bloodhounds, kept the foe at bay. Edward, now aged and sick, had reached Dumfries. The state of the country was considered at Lanercost, and an ordinance issued against all aiders and abettors of Bruce in procuring or persuading the people to rise contrary to law. Such of Bruce's accomplices or friends as came into Edward's power were inexorably dealt with. Bruce, rousing himself from the hopelessness of Rachrin, came to Arran, landed at Turnberry, and drove Lord Percy out of Carrick. His valour and prowess seemed superhuman. He encountered the assault of Pembroke and drove him back. The Earl of Gloucester was routed by him. Then the English king sent a force from Carlisle, before which Bruce retreated, and taking refuge in the marshes and forests, they found it impossible to follow him. Though his body was decayed by age, toil, and dysentery, Edward's mind was vigorous and his courage indomitable. Relinquishing the litter on which he had been borne, and mounting horse to go against his recalcitrant baron, Edward had reached the village of Burgh-on-Sands, where he halted and died, 7th July, 1307. His remains were removed to Westminster, and on his tomb this inscription was placed, *Edvardus Primus, Scotorum Malleus, Hic est, MCCCVII., Pactum Serva.*

THE GREEK LANGUAGE.—CHAPTER VIII.

GREEK VERB—PRIMARY TENSES—SUB-CLASS I., PRESENT, FUTURE, AND PERFECT.

THE verb-stem is the simplest form in which the root exists. Each leading tense and its corresponding secondary has a stem peculiar to itself. The letter pointing out the tense, and ending this *secondary* stem, is called the *tense characteristic.* Thus while λυ- is the stem proper of the whole verb, λυσ- may be taken as a *secondary* stem of the future and of the first aorist, and λελυκ- of the perfect.

There is a special termination for each person; and thus we have several elements to be combined in one verbal form—*e.g.* in λυ-σ-ω-μεν (first aorist subjunctive), λυ- is the *stem,* σ the *tense characteristic,* ω the *modal* (mood) vowel, and μεν the *personal ending.*

The tenses are distinguished one from another by (1) their terminations, (2) the augment, and (3) the reduplication.

The *terminations* are those inflexions which are annexed to the tense-stems (generally) by some connecting vowel, have the meaning and force of personal pronouns, and are called personal endings. But in the perfect and pluperfect middle no connecting vowel is required.

The following is a list of all the personal terminations of Greek verbs in ω:—

		I. Active Voice.		II. Middle Voice, and III. Passive Voice.	
		(1) *Primary,*	(2) *Historical Tenses.*	(1) *Primary,*	(2) *Historical Tenses.*
Sing.	1.	ω, α	ν	μαι	μην
	2.	σ	ς	σαι, -η, -ει	σο, -ου. -ω
	3.	ι	(ν)	ται	το
Du.	1.	—	—	μεθον	μεθον
	2.	τον	τον	σθον	σθον
	3.	τον	την	σθον	σθην
Plu.	1.	μεν	μεν	μεθα	μεθα
	2.	τε	τε	σθε	σθε
	3.	ουσι, ασι, ωσι	ν	ηνται, αται	ηντο, ατο

The *augment* is an alteration in the beginning of a word, *i.e.* a prefix—consisting of the vowel epsilon (ε)—intended to mark *past* time, but is employed only in the indicative mood, which may be regarded as the narrating mood, that which is most engaged with the mention of things past.

The *reduplication* is an intensified augment prefixed to the perfect and pluperfect tenses in all the voices, in the future-perfect passive, and in some second aorists. It is retained in all moods, even in the infinitive. It consists in prefixing the initial consonant with ε, as in τετυφα, τετυφω, τετυψομαι, τετυψοιμην, &c. If the initial consonant be an *aspirate,* the corresponding *soft* mute is used in the reduplication; *e.g.* φιλεω, I love, πεφιληκα, πεφιλησομαι.

When a verb begins with γν, κτ, πτ, or φθ, with σ followed by a consonant, with a double consonant, or with ρ, the perfect and pluperfect prefix ε only, and retain it through all the moods, as in—

		Indicative.		Subjunctive.
γνοω,	I know,	ἐγνωκα,	ἐγνωκειν,	ἐγνωκω.
κτιζω,	I build,	ἐκτικα,	ἐκτικειν,	ἐκτικω.
πτυσσω,	I fold,	ἐπτῠχα,	ἐπτυχειν,	ἐπτυχω.
φθειρω,	I destroy,	ἐφθαρκα,	ἐφθαρκειν,	ἐφθαρκω.
στεφω,	I crown,	ἐστεφα,	ἐστεφειν,	ἐστεφω.
ζητεω,	I seek,	ἐζητηκα,	ἐζητηκειν,	ἐζητηκω.

The Ionic writers frequently reject the reduplication.

In Greek, as in Latin, the present may be considered the *principal* tense, and may be taken as a point to start from in arranging in the mind a consecutive plan for the formation of the other tenses. Sometimes, as has been already fully explained in page 575, the present tense stem is the same as the verb stem; but sometimes it is strengthened or otherwise modified. Any present tense which serves for the formation of other parts of the verb is called a *theme,* and those verbs in which the verb-stem and the present-tense stem are different are said to have a double theme or stem. The verb-stem is usually spoken of as the pure theme. Verbs are classed as—(1) *pure,* those which have a vowel for the characteristic of their verb-stems; (2) *liquid,* those whose stems end in λ, μ, ν, or ζ; and (3) *mutes,* those whose stems end in any one of the nine mutes and not in any of the semivowels or double letters; for σ (sigma) is never considered a characteristic of the present [but of the future]. In baritone verbs the present tense, according to Dr. J. W. Donaldson, "always shows the root under some modification or increase, the genuine root (*i.e.* the verb-stem) being in most cases preserved in the so-called second aorist." To a similar effect, though of somewhat wider implication, is the view of Professor George Dunbar—(1) that "most of the presents in use are of secondary formation," and (2) that "others of an older date, and such as probably were employed at an early stage of the language, form the bases of most of the tenses." In accordance with this view he affirms that "Every tense of the Greek verb, in all the voices, came either from the present in use, or the original present, with the exception of the pluperfect, which is always formed from the perfect, as being, in fact, the imperfect of the perfect. Thus the only tenses

that are derived from the new present τύπτω are the imperfect active and the present and imperfect middle and passive; all the others come from the original present τύπω, with the exception of the future, active and middle." Hence he contends, for example, that "φύγω, I fly, ought not to be considered as an assumed present to account for ἔφυγον, but as the original present, of which ἔφυγον was the imperfect, afterwards used with the time of an aorist when a new present and imperfect came to be formed."

It may be accepted, for all practical purposes, in the study of Greek, that all its verbs, whether they end in ω or μι, have three principal parts, the present, perfect, and future. The formation of all other tenses entirely depends upon these.

The primary tenses of the Greek verb may be arranged thus, very much as in Latin :—

λυω,	I loose or am loosing,	Present.
λελυκα,	I have loosed,	Perfect.
λυσω,	I am about to loose,	Future.

Regarding, as we have done, all verbs in ω as constituting the first conjugation (p. 766), being as it is by far the most extensive, we have to note that the verbs comprised in it may be divided, for distinction's sake, into two subclasses—(1) baritone verbs, and (2) contracted verbs; but this does not materially affect the forms of the conjugation, and in actual use a single paradigm may be made to serve for all practical purposes as a synoptical view of all the (possible) varieties of voice, mood, tense, number, and person that can occur in the usage of verbs. It is a matter of considerable practical importance to know, in regard to mood, this general fact :—The indicative adopts *short vowels* in its inflexions, while the subjunctive takes *long ones*, and the optative *diphthongs*, as λυ-ε-τον (indicative), λυ-η-τον (subjunctive), λυ-οι-τον (optative).

In the belief that the study of the Greek verb may be considerably simplified by presenting at one view those parts which are similar in their formation, and thus gradually bringing the whole before the mind in an easily remembered classified order, we supply now a paradigm of the conjugation of a verb in the three primary tenses of all the moods and voices. The verbs given in the Infinitive are to be used first. The parts of these to be used are indicated in the column headed "tenses." The terminations of the several persons in each mood are given across the table; the same *stem* is to be used before each, as may be seen in the following example, in which the stem has been inserted :—

Present, I strike.

	1.	2.	3.
Sing.,	τυπτω,	τυπτεις,	τυπτει.
Dual,	——	τυπτετον,	τυπτετον.
Plu.,	τυπτομεν,	τυπτετε,	τυπτουσι.

Future, I shall strike.

	1.	2.	3.
Sing.	τυψω,	τυψεις,	τυψει.
Dual,	——	τυψετον,	τυψετον.
Plu.,	τυψομεν,	τυψετε,	τυψουσι.

PARADIGM OF THE TERMINATIONS OF VERBS

IN THE PRESENT, FUTURE, AND PERFECT TENSES, IN ALL THE MOODS AND VOICES.

VERBS—λυ[ειν], I wash, τυπτ[ειν], I strike, τρεπ[ειν], I am turning [some person or thing].

TENSES.		MOODS.					
Active Voice.		*Indicative.*	*Imperative.*	*Optative.*	*Subjunctive.*	*Infinitive.*	*Participial.*
Present, having as stem λυ, τυπτ, τρεπ, and Future, having as stem λυσ, τυψ, τρεψ.	S. D. P.	ω, εις, ει, — ετον, ετον, ομεν, ετε, ουσι	ε, έτω, ετον, έτων, ετε, έτωσαν or όντων.[1] (Fut. none.)	οιμι, οις, οι, — οιτον, οιτην, οιμεν, οιτε, οιεν.	ω, ῃς, ῃ, — ητον, ητον, ωμεν, ητε, ωσι. (Fut. none.)	ειν.	ων, ουσα, ον, οντος, ούσης, οντος.
Passive and Middle Voices.							
Present, λυ, τυπτ, τρεπ, and Fut. λυσ, τυψ, τρεψ, middle, and λυθησ, τυφθησ, τρεφθησ, passive.	S. D. P.	ομαι, ῃ (ει),[2] εται, όμεθον,[3] εσθον, εσθον, όμεθα,[3] εσθε, ονται.	ου,[2] έσθω, εσθον, έσθων, εσθε, έσθωσαν or έσθων. (Fut. none.)	οίμην, οιο,[2] οιτο, οιμεθον, οισθον, οίσθην, οίμεθα, οισθε, οιντο	ωμαι, ῃ,[2] ηται, ώμεθον, ησθον, ησθον. ώμεθα, ησθε, ωνται. (Fut. none.)	εσθαι.	όμενος, η, ον.
Perfect, λελυκ, τετυφ, τετροφ.	S. D. P.	α, ας, ε, — ἄτον, ἄτον, ἄμεν, ἄτε, ᾶσι.	(Terminations like the Present.)	(Terminations like the Present.)	(Terminations like the Present.)	έναι.	ῶς, υῖα, ός, ότος, υίας, ότος.
Perfect, λελυ, τετυμ, τετραμ.	S. D. P.	μαι, σαι, ται, μεθον, σθον, σθον, μεθα, σθε, νται.[3]	σο, σθω, σθον, σθων, σθε, σθωσαν or σθων.	μενος, η, ον, the participle with optat. of εἰμί, εἴην, εἴης, εἴη, &c.	μενος, η, ον, the participle with subjunc. of εἰμί, ὦ, ᾖς, ῃ, &c.	σθαι.	μένος, μένη, μένον.

[1] This *dissyllabic* termination is the more common form used in Attic Greek. It must not be mistaken for the *gen. plur.* of a participle.

[2] The second person from μαι ought properly to have been σαι. But when appended to the root by a connecting vowel, the σ has been thrown away; and thus εσαι, for instance, has been contracted into ῃ, Attic ει. So ου is for εσο; οιο opt. for οισο; ῃ in subj. for ησαι.

[3] The extended form (used even by Attic poets) was μεσθον, μεσθα.

EXERCISE.

The following verbs may now be conjugated in the same way:—ἀλλαττω, I change; βαπτω, I dip; ἁρπαζω, I snatch; δρεπω, I gather; δερκω, I see; διωκω, I pursue; βλαπτω, I hurt; λεγω, I say; γραφω, I write; κρινω, I judge; κρυπτω, I hide; λουω, I wash; βλεπω, I see; παιω, I strike.

Take the several verbs whose present, future, and perfect have been supplied (pp. 576, 672), and run over their several tenses, moods, persons, and numbers.

We recommend the student, by frequent reference and repetition, to fix and impress these tenses indelibly on the memory. When these have been so mastered that they can be repeated glibly and with the aptness of habit, the remainder of the verb will be found easily manageable. Knowledge is the key to knowledge, and this lesson being thoroughly acquired will impart the habit of conjugating in thought correctly and promptly.

the game gained by wide practical experience of it, (2) keen interest in the game, (3) eyes and ears in perfect condition, (4) good common sense, (5) rapidity of decision, (6) pleasantry, affability, and reasonableness, without proneness to give reasons. They pitch or supervise the pitching of the wickets, give the word to "play" at each innings, and they adjudicate upon disputed points, but do not direct or interfere with the plan and carrying out of the playing of the game.

Scorers.—Two are chosen, one on each side, to keep and mark the score-sheet and draw up the bowling analysis, *i.e.*, a record of (1) overs, (2) maidens, (3) runs, (4) wickets, [and (5) averages.] Each party's score is to be kept separate. Every striker's runs are to be marked under his name individually—(1) his innings, (2) how put out, (3) overthrows, (4) lost balls, (5) wides, (6) no balls, (7) byes. In doing so the following contractions are usually employed:—*b.* bowled, *c.* caught, *st.* stumped, *h.w.* hit wicket, *l.b.w.* leg before wicket, *o.* overthrow, *w.* wides, *l.b.* leg-byes, *n.b.* no balls, B. (at foot of score) byes, M. maiden over, W. wicket gained.

Fielders have each special duties to perform, and receive designations which indicate them. These are:—

1. *Wicket-Keepers.*—Upon these much responsibility rests. Their duties are—(1) to stop the balls when the striker misses them; (2) to stump him—*i.e.*, touch his wickets or knock the bails off them—when he is off his ground; and (3) to catch the ball and knock the wickets down before the batsman, when running, can ground his bat over the popping crease. He may stand any distance, from half a yard to 2 yards, behind the stumps; but never so far off as to be unable to put down the wickets without moving his feet. It is scarcely possible for him to take a graceful position; his attitude should be somewhat stooping, his left leg well forward, his hands pretty close, and his eye alert on every motion of the ball.

The Wicket-keeper.

He ought never to move his feet till (1) the batsman has hit the ball, (2) or the ball is in his hands, or (3) has passed out of them. He ought to be more anxious to *catch* than to *stump*—being very careful not to go too near in taking leg-balls, lest he receive a blow from the bat. As he is behind the striker, he can often serve his own side well by signalling to the fielders to move nearer or farther off. He, as well as every other catcher, should avoid jerking his hands forward to snatch the ball, but ought so to manage his hands that the ball may strike upon and be received by the palms. Straight and off-side balls should get more attention from him than leg-balls. When a hit is made he ought at once to get on the side of the wicket farthest from the ball, and wait quietly but watchfully till it is thrown in. As soon as the ball has been thrown in to him from Long-stop, he should move forward, unless the batsmen are running, and send it off gently into the bowler's hands.

2. *Long-stop*, whom we have just mentioned, whose duty it is to prevent byes, should place himself behind the wicket-keeper, at a convenient distance, though not too far away from the wicket. When slows are put on, Long-stop's place is generally made about 12 yards behind the bowler's head. So soon as he gets the ball he should throw it into the wicket-keeper's hand, and scarcely ever over to the bowler, for he has seldom any one to back him up, and overthrows too often give chances for runs. He should try to save runs on the leg-side, help to back up Short-slip, and may do good work, as is quite permissible in the case of rashly run byes, in throwing at the wicket-keeper's wickets rather than his hands. He ought to keep cool, watch keenly, and throw quickly yet surely.

3. *Point* should have a place in line with the wicket, and generally from 5 to 15 yards from it on the off side—that depending on (1) the pace of the bowler, (2) the style of the batsman, and (3) the condition of the ground. When the bowling is slow he should stand in pretty near, catch smartly, and throw safely.

4. *Cover-point's* position varies according to the styles of the batsman and the bowler—farther out in the field than point or mid-wicket, but on a line which would pass nearly midway between them. He must be agile and knowing; the balls he has mainly to field are cuts and square off-drives.

5. *Mid-wickets* (*i.e.* Mid-off and Mid-on) stand on the off side, about 7 yards from the wicket—halfway between the long-fields and the striker's wicket. They have much the same duties to perform. Many catches ordinarily come to them. They must both back up behind the bowler—*Mid-off* when the ball is thrown in from Long-leg, Short-leg, Long-stop, or Mid-on; and *Mid-on*, when the throw is made from Mid-off, Cover-point, Point, and Third-man.

6. *Short-slip's* place should be some 2 or 3 yards off behind the wicket-keeper, whose position he takes should he go from the wicket after the ball. He needs to have safe hands and a firm grip, and to be cautious lest the ball strike his face.

7. *Long-slip* holds the same relative position to Short-slip as Cover-point does to Point, and he should back up Long-stop.

8. *Long-on* and *Long-off* stand deep afield respectively on the *on* and *off* sides. They ought to be swift in running, good at catching, excellent in throwing, and smart in their lookout. [*Extra Long-on* occupies a place midway between these, and his main duty is to look after *slows*. This place is generally taken by Long-stop or Third-man.

9. *Third-man* stands between Point and Short-slip, about 12 yards off in direct line with the bowling crease, but going close or deep as the batsmen are quick or slow. He is expected to stop every ball that comes his way.]

10. *Leg* stands nearly at the same distance behind the wicket on the on side, as *Long-on* does on the other. [*Short-leg* stands near the batsman's umpire, and his duty is to attend to balls played away for safety; and *Square-leg's* place is far out behind Short-leg, square to the wicket.]

On-side is to the left of the wicket and that towards which the batsman naturally hits; *Off-side* is the contrary. The "admonitions to fieldsmen" have the sanction of the best known experts:—(1) Keep a good look-out; (2) always try for a catch; (3) use both hands if possible; (4) don't dash in hurriedly or flurriedly; (5) when the ball is hit straight towards you keep your legs close together; (6) pick up balls and throw them with a single action; (7) always throw towards the wicket-keeper's head, or so that the ball may bound towards the bails; (8) always back up when the ball is thrown in, without going too near the wicket-keeper or bowler—keeping about 8 yards from either; (9) go wherever the captain or the bowler desires you; (10) don't wear a coat or jacket, but a sweater; don't put your hands in your pocket or a pipe or cigarette in your mouth, or have anything else in your eye or your mind but the ball and what you have to do.

We here subjoin some hints and observations intended for the chief players in a competition:—The *Captain.* One of the most important duties of the captain is to arrange the order in which the batsmen are to play, and having once done so he ought to hold to it as, unless in some unlooked for difficulty, irreversible. The *must be* has a wonderful effect in steadying nerve and stimulating verve. He should be watchful, critical, and encouraging, but he should never, while play is going on, scold or be sarcastic. That annoys, unnerves, vexes players and depresses them. One should do nothing to

lessen the likelihood of success. The endeavour to win is vastly helped by a suave and genial manner. His next task is to allocate his bowlers. That needs tact; he must conciliate and yet dictate. The one on whom he can most surely rely must be put on where and when he suits best for gaining the game. Pace, muscle, and mode of delivery each count for much, all for more. Captains should command as if advising, and counsel so as to ensure dutiful compliance. His duty is to inspirit his own side and dispirit his rival's by choosing bowlers who use different styles, and to put on the best men in their best form, and in the most advantageous order. "The placing of the field" is often a point of great perplexity, and the organization and management of the fielders demand much tact. The fieldsman who by instinct or experience—and better by both combined—has the faculty of anticipation in active development, and can judge how bowling will tend and how a ball is likely to be taken, and who can therefore know where and how to place himself to act his part deftly, even before the hit of the batsman is made, is invaluable. A captain may do much to ensure success (1) by turning the thoughts of his fieldsmen in training to such points as these—where should I stand? when and how should I back up? how ought I to receive the ball? to which end should I throw? and (2) asking them to practise decision. The captaincy of a team is a most onerous position. Each side has its own captain—supreme in command. These toss for (or otherwise arrange) who is to have the innings. The winner chooses two batsmen from his team, who take their places at the wickets. His rival appoints (1) a bowler, (2) two wicket-keepers, whose duty it is to outmanœuvre the batsmen, and then (3) distributes his fieldsmen in what he regards as the best arrangement for his side's interest. Many captains choose for their own the office of wicket-keeper.

11. *The Bowler.*—The object of the bowler is to bowl out the batsman by striking down his wicket, or so to deliver the ball as

The Bowler.

to cause the batsman to give a catch-ball to his rivals, or let the ball come into the hands of the wicket-keeper in accordance with the rules of the game. Each bowler delivers an *over*, *i.e.* the number of balls to be successively bowled by him to the batsman at the same wicket. It was formerly fixed at *four*, now it is *five*, and may be *six*. The same bowler must not bowl two consecutive overs in one innings; though he may change ends as often as he pleases. When the last ball of an over is finally settled in the wicket-keeper's or the bowler's hand, it is the duty of the umpire to call "Over," and the ball is thereafter to be considered *dead*.

The art and craft of bowling are difficult of attainment, and the position of bowler is really the most important in the field. He wields the instrument which is the very heart of the game. To him belong less flash and dash but greater ingenuity, keenness, alertness of eye, and expertness of hand than any other. Pace, flight, spin, and twist have all to be communicated to the ball by the concentrated skill and power of the bowler, not as applied mechanics only, but as a scientific knowledge of force and motion, and the art of using these adaptedly to each occasion that arises, as well as a philosophic acquaintance with tempers and temperaments, and experience in the art of outmanœuvring the batsman, however skilful, while giving unexpectedness to the work of the various fielders. Every legal wile and dodge which may outwit the batsman and cause him to play short of his purpose, or against his intention, or otherwise strike at disadvantage, may be used by him. The bowler knows that every ball which he propels is endued by him with a certain force which may be more or less complicated in its flight by being spun through the air at differing heights and speeds, (1) from left to right, (2) from right to left, (3) with an upward motion, (4) with a downward motion, and he has to entrap the unwary players by his variations of pitch and direction as well as by his dexterity in taking advantage of any peculiarity of the ground, the weather, the disposition of the fielders, or the mannerisms of the strikers. The judicious bowler will hold the ball not in the hollow of his hand but in his fingers, having his fingers across the seams to make his catch secure, and to cause it to take a twist. He should see that the ball is good and well made, and before beginning to play with a new ball will rub it a little on the ground to roughen it a bit to take off its slipperiness, and make it take on the precise effect he wishes to give it. A new ball goes off the bat in a cleaner and firmer way than an old one, and makes it more difficult to get his rival "bowled out speedily." When about to deliver a ball, the bowler should take a run of 6 yards or so, that he may gain the proper swing of his arm. He ought also to bowl to both sides of the wicket; change his pace, pitch, length, and style cautiously and puzzlingly to the player. Nor should he begin to bowl too fast, otherwise he will tire himself too soon and lose the management of the ball. It is right to pitch up well to the batsman; to give an easy hit occasionally. Balls pitched well up to the bat, compelling the batsman to play back instead of forward, are often effective; as are also those bowled over or round the wicket, and those which twist from the off stump towards the leg.

The technical names of the balls are given rather from the batsman's than the bowler's point of view. *Full-pitch* is a ball which reaches the striker's wicket without touching the ground, (1) the high dropping pitch making either for the top of the wicket or a few inches in front of it—difficult to bowl accurately, and hard to play properly for fear of hitting the wicket; (2) the *medium* (or middle) full-pitch, so bowled as to hit the stumps near to the top. This tempts the batsman to run out to hit at it, and when he does so lets it pass over the top of his bat, or if he hits it, does so with the top or splice of his bat, whereupon the ball rises high into the air and affords a good catch; and (3) the *ordinary slow* full-pitch, which comes to the batsman about knee-high—the easiest of all balls to hit, though when sent at varying speed and length it frequently makes a wicket fall. It should be premised that the ball must be *bowled*, not merely thrown or jerked, and must be delivered with one foot on the ground *behind* the bowling crease, and the other *within* the return crease.

Tice is almost like a full-pitch—extremely so. See Yorker. If the reach is long it should be played forward by the batsman; if not, it ought to be blocked.

Long-hops are balls which strike the ground near to the bowler and do not again touch it till they are almost at the striker's wicket.

Lobs, underhand slows. These balls ought to be delivered after a long and quickish run, and with such pace as will prevent the batsman from hitting before it pitches and compel him to play forward to it.

Volley, a flying ball. See Full-pitch.

Half-volley, a ball which rises from the pitch and is to be hit just as it rises.

A *ground ball* (or *sneak*), a ball which is so pitched as to touch the ground near to the bowler and traverses the ground till it comes within the batsman's reach. It is best met by a good forward straight bat.

Shooter, a ball which, after the pitch, does not rise, but keeps rolling along the surface of the ground. It is rather the result of some accident than of the bowler's skill.

Yorker, a ball which nearly reaches the wicket without touching the ground—in other words, one which, looking like a half-volley as it approaches, pitches within the crease, and gets directly underneath the striker's bat. The only way to treat such a ball safely is to play it forward—meeting it with the bat as if it were really a full pitch.

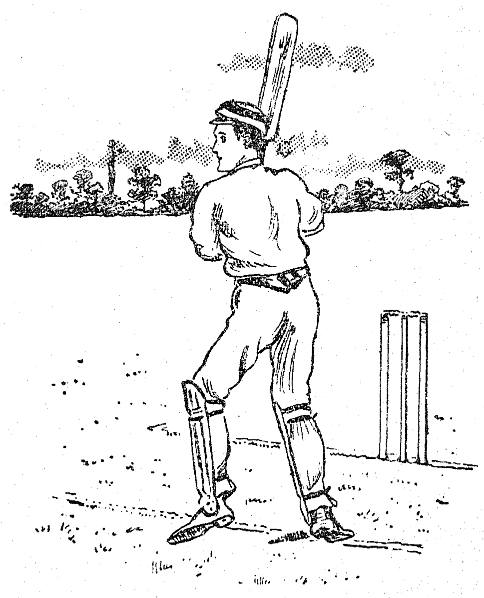
Wides are balls bowled over the batsman's head, or so tossed as to be beyond the reach of the striker; but if the striker should by any means bring himself within reach of the ball no run shall be put down on its account.

"No ball" is the cry of the umpire if the bowler should, in any preliminary act prior to the delivering of the ball, or while actually delivering it, raise his hand or arm above his shoulder; for a ball bowled with an impetus gained by the sweep of the arm above the shoulder attains such a force as to be dangerous to the batsman. The bowling therefore must be delivered from either the level of the shoulder or below it. This precaution has, however, been somewhat relaxed, and balls may now, in certain circumstances, be delivered with the arm above the shoulder. Slang and local designations we do not give, but only those which belong to the *technique* of the game.

12. *The Batsman* or *Striker*.—The practical batsman ought to study well those special positions which are most natural to and convenient for himself—yielding at once the greatest freedom and force of frame, securing the firmest yet most readily changed footing, and the easiest concurrent concentration of muscular activity in the doing of any definite design.

The Batsman.

Nature and experience are here the battist's very best teachers. It is not advisable to select any other player's pose for imitation. Everyone's mass of muscle, in relation to his general framework and its habits of action, so differ, that what is best for one person is not the best for another. In play of muscle or of mind individuality is valuable. It is this which gives rise to the great diversity to be seen in the position before the wickets taken by experts in their method of batting. There are, of course, certain advantages found in their special positions; but it is quite certain that no single pose can be described as the one type which should be adopted by all players, or even the most to be preferred by those who aim at having the best. Imitation almost always constrains one so that it injures his real dexterity in play; and even the best intentioned directions may, in this way, mislead. In this, as in so much else, the maxim holds—"to thine own self be true." Find from your natural habits of muscular activity that pose which, in your own experience, gives your strength and skill the freest scope, and rewards



The Drive.

them with the best results, and hold to it. But this is always to be studied with reference to the aims and laws of the game and within the conditions under which all recreation should be taken. Hence, while we may not commend any individual's special pose for imitation, we may justifiably gather up, from observation and experience, a general idea of what has been found best by the best players; and, in the shape of hints, suggest what it may be wise to observe and use as aid in determining what is best to do—or to avoid and leave undone.

Practical batting requires a firm, steady pose of body, a free swing of the arms, pliancy of spine, a sharp eye, and a

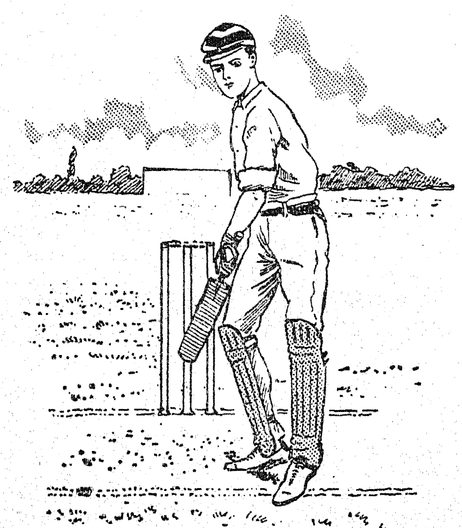
The Cut.

ready decisive mind. In the hitting of a ball with a bat we really describe a segment (pp. 11, 98 *ante*) of a circle, with the body as a centre and the arms and bat as the radius. The concentration of force to be applied to the ball is acquired

during the circular motion of the arms and bat as they travel round to the point of the ball's impact. The more swiftly and vigorously, if skilfully, the bat is whirled, the greater the acquired momentum that can be transferred to the ball; in other words, he who whirls the bat most swiftly through its circular sweep hits the most powerfully. Hence the

Forward-play.

importance of pose. It should be composed and firm. In taking position (1) let your attitude be a firm one; (2) stand at your full height, and with your bat "touch block" lightly or "guard" to ascertain the correct line of the wicket, and know where to place your feet; (3) keep the left shoulder and elbow well forward, and when playing the ball work your arms freely and easily from the shoulders—not the elbows, as that lessens your sweep; (4) throw your bat back by the play of the wrists, so that it may return and meet the ball's impact effectively; (5) study the timing of your hits that they may go "clean" and "sweet" from that part of the bat which you know by experience suits your play



Back-play.

best—say, somewhere about three-fourths down the blade; (6) "the bat should hit the ball and not the ball the bat;" (7) avoid wasting your own power and the force of the bat's impetus by hitting the earth when a half-volley, or a ground-ball or "sneaker" tempts your play. To pose well, to swing the arms and play the wrists well, and to time the hits well are the A B C of batting.

Batting needs discretion in the way of taking the bowling and making hits. The bowler's aim is to lead the batsman to forsake his ground that he may be stumped, or to discomfort him in hitting. As he varies his bowling so should the striker alter his play. So placed as to have a view at once of the line of the wicket and the course of the ball, every straight ball which comes fairly within command should be met straightly. In playing them have the end of the bat inclined backwards towards the top of the wicket, so that it may be in position and height to be brought down plump and with force on the approaching ball, at its minimum of momentum. In the gauging of this, and the discriminating of lengths and non-lengths, lie the genius of batting as to "playing forward" towards the field, or "playing backward" near the wickets. In playing forward the batsman should stand so that he may stretch out his bat about two feet beyond the popping crease if necessary. He should play every ball of which he can command the pitch with a straight bat, so as to hit the ball on the rise, and yet, if it shoots, have the bat in a position so near the ground as to prevent the ball escaping his stroke under the bat. When the pitch of a ball is beyond the command of the striker, so that he cannot hit the ball at the pitch, he must play backwards so as to prevent it from becoming a "bailer" or making a

The Leg-hit.

"bye." In playing backward longer time is gained to see the ball and gauge the pitch, but the time for hitting is shortened, and decision must be instant (see illustrations). When naming and defining the balls (see p. xxvi) we have indicated how the differing bowlings may be met. The further following definitions and illustrations we add as explanatory of other technical cricket terms, viz. the *Drive*, a direct playing-forward stroke: hit the ball straight along its path in the line whence it came, or to either side of the field, *on* or *off*, as the batsman sees fit; the *Cut* is a stroke made from a rising ball, before or behind point, to the *off* side (see Field Plan, p. xxiv); the *Leg-hit* is one made by turning round at a ball which has been so pitched as to break in or screw towards the leg stump. It is very difficult to play, and the incautious striker is frequently caught at the wicket by short or long slip, and it may be by point when the ball comes in sharply. The driving player must sedulously observe when the bowler drops the ball at a shortening pitch. The batsman given to back-play should watch intently when the balls are sent closer and closer to the wickets; and every player ought, with a keen eye, to watch the biased bowling, which gives the ball a twist after reaching the ground. Observation and experience are the best instructors in the art of good, clean, effective batting.

The batsman is "out" in the *ten* following specified circumstances, under the rules indicated by the Roman numerals: (1) if either of the *bails* be bowled off, or if a *stump* be bowled out of the ground [xv. Under this rule a batsman is "out" even if, while in the act of playing, his hat, being blown off, shall knock the bails off. It hence becomes necessary to watch that the bails are not dislodged by the feet, hands, or anything belonging to the batsman.] (2) If the ball, from (*a*) the stroke of the bat, or (*b*) the hand but not the wrist, be caught before it has touched the ground, although it be hugged to the body of the catcher [xvi.] If, in striking, or at any other time while the ball shall be "in play," *both* his feet shall be (*a*) over the popping crease and (*b*) his wicket put down—except his bat is grounded within it [xvii.] (4) If in striking at the ball he hit down his wicket [xviii.] (5) If, under the pretence of running or otherwise, either of the strikers prevent a ball from being caught, the striker of the ball is [penalized] "out" [xix.] (6) If the ball be struck, and he, wilfully, strike it again [xx.] (7) If, in running, the wicket be struck down by (*a*) a throw, or (*b*) by the hand or arm (with the ball in hand), before his bat (in hand) be grounded over the popping crease; but if *both* bails be off, a stump must be struck out of the ground [xxi.] See note on (1) in brackets. (8) If any part of the striker's dress knock down the wicket [xxii.] (9) If the striker (*a*) touch or (*b*) take up the ball while "in play," unless at the request of the opposite party [xxiii.] (10) If with any part of his person he stop the ball—which, in the opinion of the umpire at the bowler's wicket, shall have been pitched in a straight line from it to the striker's wicket and would have hit it [xxiv.] As to running, the following points have been settled by rules xxv.–xxvii. (1) "If the players have crossed each other, he that runs *for* the wicket which is put down is 'out.'" (2) "A ball being caught no run shall be reckoned." (3) "The striker being run out, the run which he and his partner were attempting shall not be reckoned." (4) "If a 'lost ball' be called, the striker shall be allowed six runs; but if more than six shall have been run before 'lost ball' shall have been called, then the striker shall have all that have been run." The striker should call every time when the ball is hit in the front of the wicket; the non-striker in all ordinary circumstances when the ball is hit behind it. The person who runs the risk, and he who sees danger, have really the call. The striker ought not to look after a ball he has hit, but should trust to the non-striker to give him the call when it is safe to run. If a catch has been sent reasonably high, a run should be taken; if it is caught the case is no worse, if it is missed the case is bettered. The first run should be done as speedily as possible, the bat should be grounded within the popping crease instanter, and turning quickly round a glance will tell whether a subsequent one may be successfully taken. If a *bye* is being run, the running should be straight down the wicket; at other times run wide of the wicket to save it from being cut up. The call whether "run" or "no" should be given loudly and distinctly. A batsman's boots should fit comfortably and be properly spiked, his gloves ought to be nice in feel and fitting, and all fastenings about his pads or dress require to be carefully secure before he begins his innings. A scarf is preferable to a buckled belt.

The enthusiastic student of cricket desirous of training himself to defend a wicket by batting, in season or out of season, may find help thus:—Take a cricket or other similar hard ball, enclose it in a net-work bag, fasten to the bag a long, strong string, and, having a fairly thick rope stretched from two points about 10 feet high (gymnasium poles, the walls of an outhouse, or suitable branches of two trees), suspend the netted ball from the rope so that it may all but reach the floor or ground; hit away at the ball with the bat, and as it returns strike at it again and again. You may provide yourself with practice in "the *cut*" to try your eyes and your wrists as it sways to your "off" side, and as it swings to the "on" side you can have *leg hits*, which call for the exercise of every muscle to the utmost, and *tosses* to drive forward as many as you like. Besides these actual cricket hits, you may gain much knowledge of force and impact; of the effect of hits on different portions of the ball, central and excentric; hitting the ball with the bat in various attitudes, at different altitudes; as well as exercise in handling the bat to purpose, and accustoming the muscles to the requisite motions of legs and spine, shoulders and arms. The technical description of all the possible hits which the batter may encounter would greatly exceed the limits and extend beyond the aim of "The Home Teacher," which is to introduce the reader to a study and set him somewhat forward on his way, rather than to perfect him in all the *minutiæ* of it. We therefore commend those who wish to acquire proficiency in the game to make a study of it as it is played by experts, and gain by the eye of experience, all at once, what could only be instilled into the mind by pages of words requiring continual definition and repetition more likely to confuse than to inform.

CHAPTER VI.

GOLF.

Golf, from an athletic and social standpoint, has now become one of the most important and attractive of our national games. To anyone even moderately familiar with the conditions and surroundings of golf this result is not at all surprising. It is emphatically an open-air game, and is playable, more or less pleasantly, within a considerably elastic sweep of conditions as to players, places, and weather. The players may be of any age or sex; the place may be one of the ideally perfect sea-side links, such as St. Andrews, Musselburgh, or North Berwick, or one of the less perfect but more picturesque inland courses, like the Braids at Edinburgh—a mixture of hill and dale, with an accompaniment of panoramic views such as can hardly be equalled anywhere else; the weather as well may be anything—shade or shine, calm or storm—yet, if needful, the game may be played with varying pleasure and success. It is in this elasticity of playable conditions that the superior attractive power of golf consists. The conditions vary continually in the player himself as well as in his surroundings; the resulting play must to some extent vary proportionately. But here increasing skill comes in, and enables the player, in a measure, to triumph over disadvantages, and turn them into helps in place of hindrances, thus fostering the most healthful of all feelings—that man is the master, not the slave, of circumstances. The sense of buoyant hopefulness induced by this conviction must be experienced to be fully understood.

Golf is found to be popular at its earliest appearance in historical records. Queen Katherine, wife of Henry VIII., wrote to Cardinal Wolsey, August 13, 1513 (three days before the battle of Spurs), "All his (Henry's) subjects are very glad to be busy with the golf, for they like it for pastime"—as if it were quite an everyday game. The Scottish Parliament of 1547 found the popularity of football and golf seriously interfering with the time and attention needed to attain the skill in archery which would enable the Scottish bowman to hold his own on the battlefield against the cloth-yard shafts of his English foe. They therefore solemnly decreed that "Futeball and Golfe be utterly cryed downe and not to be used," while the time thus saved was to be employed perseveringly in practice at the bowbutts, as being essential for the preservation of the freedom and well-being of the nation. This stern enactment was repeated in the statute-book at intervals of a generation, till the general use of gunpowder in warfare, and, above all, the union of the crowns of Scotland and England in the person of King James VI., left the nation free to enjoy their chosen game without the feeling that they were doing so to the endangering of the national safety.

What is this game of golf, which has not only maintained its popularity for at least four centuries, but, almost within the last decade, has so widened its sway that it is now found in all quarters of the world? In Britain it certainly would be easier to find a hundred places where it is in full swing than one where it is not. The game is very much to-day what we gather it was when it first appeared on the horizon of history. Modifications there have been, no doubt, in the materials made use of and the rules by which

they were employed in the game, but in its essential features the golf of to-day is the golf of four centuries ago. What follows is nothing more than an outline sketch of the principles and practices of the game as played at present. Should this sketch, as we trust it may, excite a desire for further details, there are many special text-books which would certainly repay careful perusal and study. If this is preceded by a few games under the experienced eye of a golfing friend, or, still better, under the instruction of a competent professional caddie, progress will be swift, sure, and pleasant. It is our aim in this chapter, however, to give in short compass such an idea of the game as will enable anyone of ordinary intelligence and perseverance ultimately, with self-help only, to play with ease and certainty.

To have an adequate idea of golf as a pastime we require to consider—(1) the place of play, (2) the tools or instruments of play, (3) the rules of play, and (4) the most effective way of using the instruments in play.

I. *The Place of Play.*—This is known as the golf links (if on the sea shore), the golf course, or the golf green (if inland). When of the ordinary full size, this consists of a stretch of greensward 1½ or 2 miles long by, say, half a mile broad. This is usually divided into nine successive portions going out the one side, and nine coming in the other. The portions are of unequal length, varying from 100 to 400 or even 500 yards. Each separate portion begins with a marked-off strip, 12 feet by 4, called the *teeing ground*, and ends with a *putting-green*—a portion of ground about 20 yards square, as level as possible, and the sole of grass as fine as can be procured, having a hole 4 inches across by 6 deep somewhere near the centre of the plot, the edges of the hole being kept unbroken by the insertion of a bottomless circular iron frame. A small flag is placed in the hole to guide the player when approaching. The ground between the tee and the hole varies according to the number and character of the *bunkers* (holes or hollows in the sand) or *hazards* (sandbanks, walls, trees, water, bushes, long grass, &c.) that may be found in it naturally. If too smooth, artificial hazards are made at suitable points, so as to give room for skill and judgment in overcoming them. The laying out of a golf course so as to make the most of the natural condition of the ground, requires the experience of a trained golfer as well as the technical knowledge of one who has made it a subject of special study. Greens already laid out are to be found almost everywhere; there is therefore no need to say more on the matter here.*

II. The *tools* or *instruments* with which the game is played are known by the general name of *clubs*, and naturally fall into two classes, according as the material out of which the heads are fashioned is *wood* or *metal*. The principal wooden clubs are drivers, spoons, brasseys, and putters. The principal metal clubs are cleeks, irons, mashies, niblicks, and putters. These are the chief classes; but varieties of these, devised to meet special circumstances and niceties of the game, are numerous. The essential clubs, however, especially for beginners, or for those even who are moderately skilled in the game, are not many. A driver, a brassey, a cleek, an iron, and a putter are quite sufficient to enable ordinary players to enjoy the full pleasure of the game, while producing more or less creditable results. In supplying oneself with these, especially if only about to make a first acquaintance with golf, the advice of a friend familiar with the game and its requirements will be of far more service than pages of description in securing clubs the best and most suitable of their kind. The *driver*, as its name implies, is a long-distance club, and is only used for teed shots, generally only the first shot for each hole, or where, in playing through the course, the ball happens to come to rest on a tuft of grass, raising it above the general level, and thus permitting the swipe or sweeping stroke of the tee being repeated. The *brassey* is so called from the sole of the club being covered with a thin plate of brass to fit it for rougher work than the driver could perform without risk of breakage. Hence it is used in playing through the course, when the lie of the ball is neither so good as to warrant the use of the driver, nor so bad as to require an iron club. The *cleek* (probably so named from the sharp *click* which results from its contact with the ball) can be used, and with good effect, when the driver or the brassey would be useless. The *iron*, in its varieties of lofter, mashie, and niblick, is employed through the course when the ball has to surmount obstacles in front, to be got out of loose sand, out of cups or ruts, or when it is desirable to drop it without much run on the putting-green. Once on the putting-green, the putter, wooden or metal, is the most suitable tool, and is almost the only club then used.

III. We have now to consider carefully the *general rules* of the game. The code of rules almost universally adopted is that of the Royal and Ancient Golf Club, commonly designated "The St. Andrews Rules." These have been often printed, with such modifications as the exigencies of time and place demanded, and can be procured without difficulty. The principles of the game are identical wherever it is played; but each course has some individual local peculiarities which are met by special regulations suited to the circumstances of the case. The principal rules form the groundwork of the following statement:—

The game of golf is most commonly played by two or four persons, either as medal play or as match play. In *medal play* the numbers that may take part in the same contest are theoretically unlimited, from two upwards. Only two play through the green together, from striking off at the first teeing ground till they have safely lodged both their balls in the last hole. The respective strokes required for each of the eighteen, or other agreed on number of holes, are duly recorded, either by an independent marker who accompanies the players, or are noted and verified by the players themselves mutually as each hole is reached. As soon as the leading pair have got a safe distance from the first teeing ground, usually when both have made their second strokes, another pair follows; and so on, until all who wish to take part are started. The rule of starting distance between successive pairs of players is observed at each teeing ground, and it is *de rigeur* that the approach shot to any hole shall not be made by the party following until those immediately in front have holed out and left for the next teeing ground. The observance of these distance rules in their real spirit conduces much not only to the pleasure but to the safety of the game. To a novice a blow from a swiftly driven golf-ball may seem a comparatively trifling matter. In reality it is very different. It is not only disagreeable but dangerous. In some instances, though fortunately in very few, death has followed such a stroke immediately. When the rules of distance are strictly observed, not in letter only but in spirit, the danger is *nil*. When all who wish to compete in medal play have thus in turn played the agreed on number of holes, the score-cards are handed in, and the total strokes taken by each carefully noted. Whoever has the smallest aggregate number is declared the victor, the next lowest second, and so on. This is the procedure in a *scratch* competition, in which each player meets as equal to his opponent. In a *handicap* competition—that is, when the approximate excellence of each player is known beforehand, and it is desired that all should start with an equal probability of victory—the inferior player, before starting, has a handicap of one or more strokes allowed him, which at the close of the competition is deducted from his actual score before the list of victors is declared. When the handicapping is based on an average of actual authenticated scores it works well, and adds greatly to the interest and pleasure of the game; but when it is given or withheld as a matter of opinion, or at haphazard, it is not unfrequently the cause of dissatisfaction and heartburning.

Match play has much in common with *medal play*. The distance rules are the same in both, as also is the order of play; similar, too, is the object of play—namely, to get the ball safely to the bottom of the hole in the fewest possible strokes. But victory or defeat is regulated, not by the aggregate number of strokes required for the whole course,

* The "Golfer's Guide," published annually, furnishes a map of the British Isles, with golf greens marked thereon. A mere look at this map will show the popularity of the game, and the numerous facilities provided for playing it in England, Scotland, Ireland, and Wales. Those greens we have named above are only samples of the different sorts, and are not invidious selections.

but by the strokes for each hole. Suppose a foursome being played—that is, two partners pitted against other two. The two opponents who are to drive off from the first tee having been settled (either by mutual arrangement or by lot), the partners play alternate strokes through the green, till the ball is lodged in the hole. The tee shots are also taken by the partners alternately; the honour—that is, of teeing and driving off first from the second or subsequent teeing-ground—being allowed to the side which lodged the ball in the preceding hole in the fewest strokes. After the ball is teed, it is not allowed to be touched by anything except the clubs until it is holed out, and by these it must only be *struck*, not *pushed* or *drawn*. Any motion of the clubs, with the bona-fide intention of hitting the ball, is counted a stroke, even though the ball be missed entirely; and any accidental motion or action of the player himself which causes the ball to shift its position, is considered and counted a stroke. If the ball merely oscillates, but does not shift its base, it does not count a stroke. In *addressing* the ball—that is, putting oneself in the position for striking—one is

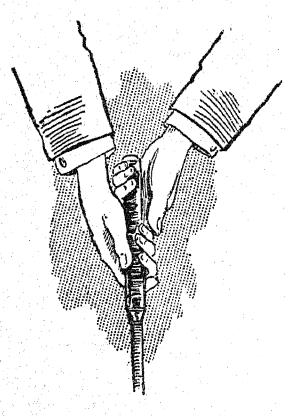
Addressing the Ball.

very apt, unless extremely careful when *soling* the club—that is, placing the *sole* or lower part of the club-head close to the ball—to touch it and so cause it to roll. Or, driving through the green, the ball may have come to rest on the edge of a small stone. The temptation to beginners is great and immediate to withdraw the stone. If this is yielded to and the ball changes its base, it is counted a stroke, and the right to play passes to the partner. Stones, or loose impediments within a club-length of the ball, may be removed if in the way of a free stroke, provided the removal does not stir the ball; but nothing growing may be bent, broken, or pulled up, nor the ground behind the ball flattened or pressed down in any way so as to help the stroke. Indeed, the stringency here is so great that when the ball happens to lie in a sand hazard the club must not even be *soled*, but the ball struck at as it happens to lie. These minutiæ not unfrequently seem irksome and purposeless to beginners, but a short and vigorous practice of them not only tends to greater precision of play but really increases the pleasure of playing. We have said that in *match play* strokes are only enumerated so far as to settle the gaining or losing of each hole. There is a special nomenclature, too, employed for this enumeration. The side that plays the first stroke is said to have played the *odds*. The first stroke of the opposite side is called the *like* (or equalizing one). After the first stroke the ball farthest from the hole is played odds, two more, three more, and so on, until it lies nearer the hole than the ball of the opponents, who then play their ball one off three, one off two or like, odds, one more, two more, and so on, as the case may be, until their ball in turn rests nearer the hole than the other. If the last played ball reaches the bottom of the hole by the like, the hole is said to be halved; but if by the odds, two more, three more, &c., the hole goes to the side holing in fewest strokes. The victorious party are then said to be one hole up. If the second hole is halved, the victors in the first hole are still said to be one up; but if the losers of the first gain the second hole, the match for the time is said to be *all square*. Thus the play is reckoned, until the agreed on number of holes, usually one round of the links, or 18 holes, has been played, or until one side has gained such a number of holes as to have at their credit one more than the number remaining to be played. For instance, suppose the victors have five holes to their side, while only four holes remain to be contended for, they are then said to have gained the match by five up and four to play. The four may be played as a *bye* match, as distinguished from the great or principal match. Suppose in this *bye* one of the sides wins the first two holes, they are then said to be *dormy* two, which means that however *sleepily* they may play the remaining two holes they cannot be beaten. The game may be halved, but cannot be lost. *Dormy*, of course, may be obtained in the great match as well as in the bye.

An interesting development of match play is the *tournament*, which is held annually to decide the holder of the Amateur Golf Championship for the year. This tournament is held under the auspices of a number of the principal golf clubs in the kingdom, who fix the place, date, and conditions of the competition. The tournament is open to all amateurs. members of any golf club who comply with the conditions. The definition of an amateur is strict and comprehensive. In substance it runs as follows :—An amateur golfer is one who has never made for sale any golfing apparatus; who has never acted as a caddie or carrier of clubs for hire after being fifteen years of age, nor at any time within six years of the beginning of the competition; who has never received any consideration for playing in a match, nor for giving lessons in the game, nor for a period of five years previous to 1st September, 1886, has received a money prize in any open competition. The various competitors are entered by the secretaries of their respective clubs, who, in forwarding the names, are held as certifying that each is a *bona fide* amateur golfer. The entries having been completed in accordance with the rules, a sort of ballot settles the order of play. A list of the entries is made, numbered 1, 2, 3, &c., in consecutive order. Slips with the same numbers, but minus the names, are put into a box and shaken up. If the total number of entries be 4, 8, 16, 32, 64, or any higher power of 2, the procedure is simple. The slips containing numbers only are drawn out one after another. The first and second drawn are identified by the name-list, and play against each other till the match is decided in favour of one or other. If playing the agreed on number of holes results in a *tie*—that is, a halved match—the play is continued till either party is one up, when he is declared victor. Meantime 3 and 4 have been drawn and set a-playing in the same way. So with 5 and 6, 7 and 8, 9 and 10, and so on, till the entries are exhausted. Should the total entries not be an exact power of 2, a modification of procedure requires to be employed. Suppose the total entries, in place of being 4, 8, 16, or any higher power of 2, should be, say, 54, in that case the actual number of entries would be subtracted from the first power of 2 higher than itself, and the difference noted. The first power of 2 higher than 54 is 64. The difference between these numbers is 10. The first ten numbers drawn from the ballot box are set aside as *byes*, and do not play in the first trial. 11 and 12 play against each other; and so with 13 and 14, 15 and 16, &c., till 53 and 54 are set off. This is called the first heat. When there are no *byes*, the victors in the first trial play for the second trial against each other in the order in which they were originally drawn—*i.e.*, the victor of the first pair plays against the victor of the second, the victor of the third against the victor of the fourth, and so on; the outcome being that there are only half the numbers playing in the second trial that played in the first. When there are *byes* the order of

the second heat is somewhat different. In the case supposed of 54 entries with 10 byes, in the first trial 22 pairs would play, 11 and 12, 13 and 14, &c. In the second heat the victor of pair 11 and 12 would be pitted against bye No. 1, he of 13 and 14 against bye No. 2, and so on till the byes were exhausted. This would take ten of the victors, leaving twelve still to be mated—that is, the victors in 41-42, 43-44, 45-46, and so on to 53-54. The usual rule is followed with these—the victor of 41-42 playing against the victor of 43-44, and so on. The result is that sixteen pairs would play in the second heat. The sixteen victors in this trial are pitted in a third trial against each other in the same relative order as before, but forming eight pairs; the eight victors play a fourth heat in four pairs; a fifth heat is played by the two pairs of survivors, while the final heat is played by the two victors in the fifth heat. The victor in the final heat is declared the Champion Amateur Golfer for the year—an honour which is truly the blue ribbon of the game, and justly very much valued and desired by every true golfer. The result of such a tournament is emphatically "the survival of the fittest." The duration of the survival in such a contest as that of which we have been speaking depends less on such knowledge as that we have already described, than on intelligent apprehension and persevering practice in the lines of the remaining portion of this sketch. Other tournaments than the one described are played frequently. The procedure, however, is almost always identical.

IV. *The most Effective Way of Using the Tools or Instruments for Playing Golf.*—In Section II. we have already indicated shortly the principal clubs essential to the game. The driver, the iron, and the putter may be taken as repre-



Commencement of the Grip.

The Grip complete.

sentative clubs, requiring, more or less markedly, different handling if they are to do their work pleasantly and successfully. Before looking at these individually, however, it should be carefully noted that motion is communicated to the ball legitimately only by a *swinging* stroke, never by a push or draw. This seems so obviously rational that one almost wonders it should be needful to mention it; yet a somewhat extended observation shows that no fault is more common or more difficult to be got rid of. It is a fatal bar to progress as well as pleasure. The modern ball—a sphere of gutta-percha, or some modification thereof—is more elastic than the ancient sewed circular cover of leather hard stuffed with feathers, and rebounds from a properly hit stroke more readily and to a greater distance. Bearing in mind, then, that the stroke in all cases partakes of a pendulum or swinging motion, let us consider how best to secure this in using each of the three representative play-tools we have named above. The stroke modifications for the separate clubs vary in degree, not in nature, and they arise partly from the make of the club itself, and partly from the purpose intended to be served by giving the club its peculiar make. The *driver* has a long tapering shaft, with more or less of suppleness or spring in it. Its office is to drive the ball to the longest possible distance. The swing already spoken of is, or ought to be, *circular*. The driver, if properly swung, should travel through three-fourths of a circle in meeting the ball. The *iron* has a shorter shaft, stiff, with hardly any taper; and when used most effectively traverses only half a circle in striking the ball. The putter has the shortest, stiffest shaft of the three, meeting the head almost at right angles. In use it ought never to traverse more than a quarter of a circle. To the driver alone is usually conceded the privilege of the *tee*—that is, the use of some means, a pinch of sand, a tuft of grass, or something else, by which the ball is artificially raised slightly above the surrounding level, so as to permit the club-face at the end of the swing to come into swift contact with any particular spot of it we may judge best suited to serve our purpose. To do this the player must, above all things, *keep his eye on the ball—i.e.,* on the identical bit he wishes to strike—or, to prevent eye-dazzling, half an inch behind it. This seems very easy, but troublous experience proves that it is not so. When the snowy ball stands out clear above its emerald surroundings, it looks a simple matter to hit it where we will. We naturally wish to send it as far as we can, and so aim at a point slightly below the middle, that we may have a skimming shot, travelling along some 8 or 10 feet above the ground, and continuing its course for a long distance even after it comes to earth. But alas! we either catch the ball too high—that is, *top* it—making it roll ingloriously a comparatively short distance in front; or we catch the ball too low, and send it straight to the clouds, to fall dead an equally short way off; or we catch it with the heel of the club, and off it goes at a tangent to the left; or with the toe, and away it flies to the right. Nay, more provocative still of evil "thoughts, words, and actions," the driver-head in tracing out its circle may pass over the ball by a clear inch or so, *missing the globe,* as the humorous slang of the green puts it; or fathoming a lower depth still, a sudden involuntary droop of the right shoulder may bring the club-head, while at its swiftest, in contact with the ground a foot or more in front of the ball, to the injury of the turf, of the club, and of the comfort of the player. The cause or causes of this chapter of disagreeable incidents may be obscure till traced to their ultimate origin. Sufficient for us to state that they can all be much modified, if not entirely prevented, by attending carefully to two things beyond what we have already hinted at. These are—(1) the method of grasping the club, and (2) the position of the body when delivering the stroke. The leathered portion of the club shaft should be grasped with moderate firmness at the point furthest from the club-head by the left hand, the right taking hold almost close below the left, but loosely—its office being to guide the stroke, while allowing it to have as much as possible of the pendulum motion while traversing the three-fourths circle of which we have already spoken. Hard gripping with the right hand tends to shorten the swing and derange the aim, and is certainly answerable for more than one of the evils we have already catalogued. A wrong position of the thumbs, too, contributes to the same trying result. They should be *bent round* the shaft, not stretched like a couple of pointers along it lengthwise. The knuckles of the fingers, when the club is in front of the player, ought to point to the ground. The stance of the player with reference to the ball when about to swipe from the tee is of equal, if not greater, importance. He ought to be standing in such a position that when, by the free swing of his arms, the club-face comes into contact with the ball, the line represented by the club-shaft should, as near as may be, form a right angle or square corner with the line of flight along which it is desired to propel the ball. This position in practice is most easily ascertained in some such way as the following:—The ball being teed about half an inch above the grass, take a swift glance at the line on which you wish the ball to travel; place yourself—feet so far apart as to give secure standing—body facing the ball, so that were both your arms stretched to their full extent in opposite directions they would form a line parallel to the proposed flight of the ball, while a line from the tee to, say, the lower button of your waistcoat would give the desired right angle. This done,

grasp the end of the club-shaft lightly with both hands—the body meanwhile being held erect—place the club-head carefully on the ground between you and the ball, but a couple of inches away from it. Shuffle back or forwards so as to allow your arms to drop to their full length in front of the body, the hands still gripping the end of the shaft. This gives approximately the striking distance. Having ascertained this without altering the

The Drive—the top of the Swing.

aplomb of the body, bring forward the left foot until it be only slightly, say 2 or 3 inches, in front of the line made by the club between the ball and the player, turning the toes of both feet a little to the right. While these latter operations (more tedious in description than in execution) are being carried out, the club-head is lifted from the ground

The Drive—the end of the Swing.

so as not to risk touching the ball. It is now to be moved over the teed ball once or twice as a preliminary waggle, and then placed carefully on the ground an inch behind and *soled* there—that is, it is allowed to rest on the ground for a second or two on its flat portion to bring the muscles to the proper tension, as well as to be a sort of final test of distance. It is then carried slowly and steadily back, rising as it goes, until the hands holding the shaft are almost directly over the right shoulder—the slacker hold of the right hand enabling this to be done with the greater safety, without the temptation to lengthen the swing by turning the head, as well as the body from the loins upward, in the direction of the back swing. Yielding to this temptation, like yielding to most others, is almost invariably followed by mischief. A heeled ball plunging into hazards off the course is poor consolation for a fuller swing got by turning the head in unison with the trunk and shoulders. The position of the player as we have now reached it is—his eyes are steadily fixed on the point of the ball he intends to strike; his left heel is slightly raised from the ground in sympathy with the pivot motion of his body from the loins to the vertebrae of the neck, which has so far followed the backward swing of the arms as to permit the club-head to go behind the shoulders at the afore-mentioned distance of three-fourths of a circle from the ball. The moment things have reached this position the muscular action is reversed. The return swing is begun slowly at first, but steadily increasing in velocity until the instant of impact on the ball, which, if properly timed, ought to be at the moment when the club-head has traversed the lowest part of its circle and is beginning to rise. This rise should not be suddenly checked, else the club-head will follow the ball once for all in a fashion of its own, memorable enough, but not quite pleasant. The

A Wrist Shot.

club should be allowed to continue the circle for a little—technically, *to follow the ball*—during which it can be brought to rest easily and gradually.

We have been almost tediously minute in describing the driving stroke, because this once acquired correctly the battle is all but won. Driving through the green is carried out on identical principles. When the ball lies so favourably as to allow the driver to be used, the conditions of the stroke are the same; the practice should therefore also be the same. When the lie of the ball from its position on the green demands the use of the brassey, everything is the same, except that the ball instead of being teed is depressed. To counteract this the club-face should catch the ball, not at the moment it is beginning to rise from the lowest part of the swing-circle, but at a point some two inches sooner. In other words, for a teed ball the lowest part of the swing-circle is, or ought to be, the base on which the ball rests; for a brassey shot, it is two inches farther on; the point of lowest depression is therefore slightly below the grass level. The same holds good should the ball be lying so badly as to require an *iron*. There is, however, a further modification of the swing in the case of an iron. Both hands grasp the shaft firmly; the swing is therefore shorter, and is slightly less circular, and more of an up-and-down character. This is more especially the case should the ball rest in a sand hazard. Then the ball is not aimed at at all, but a point in the sand three

inches behind the ball, less or more, as the slope in front, over which the ball has to be carried, varies in height and steepness. The same remarks hold good, to a modified extent, in approaches to the putting-green, which are almost invariably made by iron clubs. The paramount consideration in approaching shots is the intervening distance, and the consequent force and elevation to be given to the ball. This can only be acquired by experience. Once landed on the putting-green the way is smooth to the end. It requires nothing more than a keen eye and a correct judgment as to the line the ball should travel to the hole, and the amount of force needful to make it do so. Not more than two strokes should be required on the putting-green to lodge the ball safely in the hole. The first stroke should be aimed at the hole with so much impact as will carry the ball a few inches beyond it, but not further. It may drop in, but if not, the second stroke should infallibly settle it. The club almost invariably used is the *putter*, either of wood or metal. Some prefer the one, some the other. In the hands of a careful player either is deadly. For putting, the position is generally much the same as for driving—facing the ball, the feet nearer together, the left advanced almost to the line of the ball, knees and body bent, motion of the club almost purely pendulum, given mainly from the wrists, right forearm steadied by touching the right thigh. Glance carefully over the ground to be travelled, estimate difficulties to be overcome; this done, fix your eye on the ball, give the requisite tap, and in nine cases out of ten the ball will obey your will as if a thing of life, and you will finish your game in the happy consciousness that you have done your best to deserve success, whether you have attained it or not.

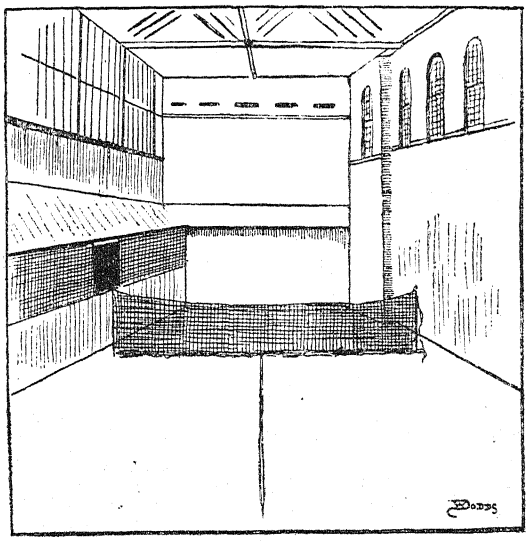
Such, in outline, is the game of golf, described from an amateur experience of a good many years. On several of the points stated, both as to principle and practice, differences of opinion exist, even among experts. The consideration of these debatable matters has been of set purpose excluded from this outline, as being more suited for adepts than learners. Our aim has been not to teach or criticise the arts and specialties of professionals, but to make smooth the way for beginners to the enjoyment of the game by the attainment of proficiency in the elements of play. This done our aim is accomplished, and play becomes a pleasure.

CHAPTER VII.

TENNIS—LAWN TENNIS.

RACKETS may be regarded as Tennis popularized, and Lawn Tennis as the same game simplified. A Tennis Court is not a very familiar object. They are few in number, and though some of these are ancient, the greater portion are of modern date, and even in these the game is seldom, and in some never, indulged in. Almost all of them are private, either belonging to the aristocracy of birth or wealth, or to exceedingly select clubs to which access is difficult, and of which the membership is rigidly exclusive. It is a "game royal," and a "courtly pastime," but not a popular, ready, everyday recreation. It possesses, however, a historical and a literary interest; for *le jeu de paume* dates back to the time of the Lydians, and areas for its play are mentioned in the annals of centuries. But it has confessedly waned as too conventional and ceremonious for an ordinary amusement, and the courts of this game of giants have become shows of what have been, as that at Hampton Court, and those at Hatfield, Coombe Abbey, Brougham Hall, and Lords'. It is noticeable that these are not uniform in size, structure, and plan. This fact suggests that the pastime was not, even in its best days, pursued on similar and well-settled lines or laws, and also that the knowledge even of experts would scarcely yield generally available instruction. Its greatest defect as an amusement is that its glories are individual, and hence fails in sociality and *esprit de corps*. Even on the most moderate scale a Tennis Court cannot be built for a less sum than £2000, while management, furnishings, and upkeep imply a considerable annual outlay. To the many "the cost outgoes the profit," so that, healthy, invigorating, and exhilarating as it is, they see in that the wisdom of "renouncing clean the faith they have in tennis." A portion, however, of the technical terms of Tennis has passed into literature, and even become embalmed in proverb and phrase.

A Tennis Court proper should, to prevent glare from the skylight, lie E. and W., having its main wall and windows N. Its floor should be of black marble or fine limestone, like Caen stone—but the latter requires to be stained. Its walls, whether of stone or brick, must be coated thickly with Portland cement with a uniformly roughened surface, and coloured to prevent "sweating" of the mortar. Hot-water pipes should be used in heating, and any artificial light employed must be kept 30 feet from the floor and be securely protected.



Interior of Tennis Court, Queen's Club, Kensington.

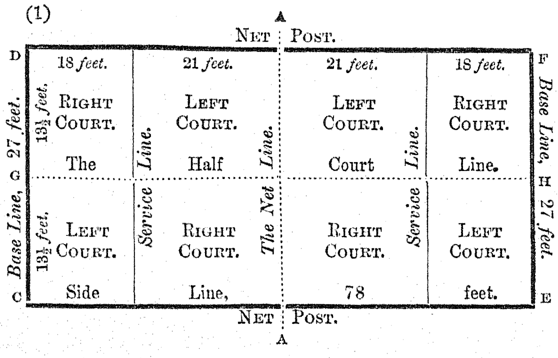
The building is rectangular in the interior, with an inner wall 7 feet high round three sides, and from this wall a sloping wooden roof called *appentis* or Penthouse. Between the inner and the outer wall a corridor 6 or 7 feet wide runs. In the inner wall, below the appentis, there are (1) a long large window, called the *dedans*, on the end wall of the service-side, through which spectators, protected by a network, may see the game going on in court; (2) the galleries, openings opposite the main wall on each side of the net; and (3) the *grille*, next to the main wall on the hazard side. At one point of the main wall there is a sloped wooden projection called the *tambour*—a timber instrument sounding on percussion—on which when the ball strikes its course is deflected across the court. Midway between and parallel to the end walls, a net, 5 feet in height at the walls and 3 feet in the centre, is stretched across the court. The lower edge of this net lies heavily on the floor to keep the balls from passing below it. Down the centre of the floor a line is drawn which divides the space into two *half-courts*. The net separates the court into two sides—(1) the *service* side, that between the net and the end wall beyond the *dedans* penthouse; and (2) the *hazard* side, that between the net and the end wall beyond the *grille* penthouse. The *service*-line is drawn parallel to and 21 feet distant from the end wall on the hazard side; and the *pass*-line from the service-line to the end wall, at a distance of 7 feet from, and parallel to, the half-court line. Besides these, there are the *chace*-lines, parallel with the end wall: (1) on the service side beginning at half a yard from the end wall, and counting each a half yard off till 6 yards' distance has been so marked—then follow some intricate and peculiar chaces; (2) on the hazard side the first chace-line is drawn half a yard from the service-line, and each chace half a yard farther on till 4 yards have been so lined. Thereafter special varieties are introduced.

Service is the starting of the ball in play; a *rest* commences when the service is delivered, and continues so long as the ball is in play; a *return* is playing back over the net—before the ball has fallen—the service, or any succeeding stroke of a

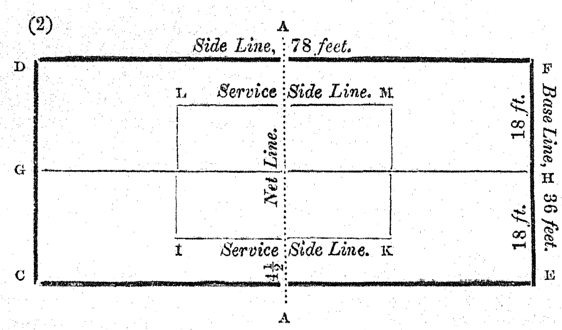
rest so as to keep the ball in play; a *strike-out* is the receiving of the service, *i.e.* the playing of the first stroke; a *good* stroke is one played according to the laws of the game; a *fault* is a stroke which does not comply with the rules; a *fall* occurs when the ball, having dropped, drops on the floor again, touches the net, or enters an opening; a *pass* is a stroke which—not being in fault—drops in the court between the pass-line and the main wall, or crosses the pass-line on the penthouse; and a *nick* is a stroke in which the ball, on dropping or falling, touches simultaneously the floor and the wall. The lexicon of Tennis is extensive, technical, and intricate, only to be understood by *habitués* of the courts who have seen the game pursued by expert players, and even then is by experts themselves sometimes subject to debate on their precise interpretation. The laws of Tennis are numerous and involved; and, as courts differ in their construction very much, many points are left unsettled by them, and are subject to "the custom of the court" in which the play takes place. The method of scoring is even more intricate, for it is difficult to make indefinite details definite in calculable results. All that is best in Tennis as a healthy and invigorating sport capable of being popularly practised and enjoyed has been incorporated into Lawn-Tennis, with the added advantage of being played in the open-air and natural surroundings; but, of course, also with the accidental disadvantage of being unavailable as a pastime in unfavourable weather.

Lawn Tennis, a game in which persons of either sex may join, is played in open-air courts. These should lie north and south, so that the sunlight may as little as possible affect the eye. Trees, because the light comes strongly through their branches and the wind varies their shadows, are not desirable near a tennis lawn. The court floor should be quite level. Turf, for the footing it gives, is preferable to asphalt, ashes, cinders, brick-dust, gravel, or tar-paving. More easily understood than any description will be the following plan of a single-handed court (1) and of a double-handed court (2).

(1)



(2)

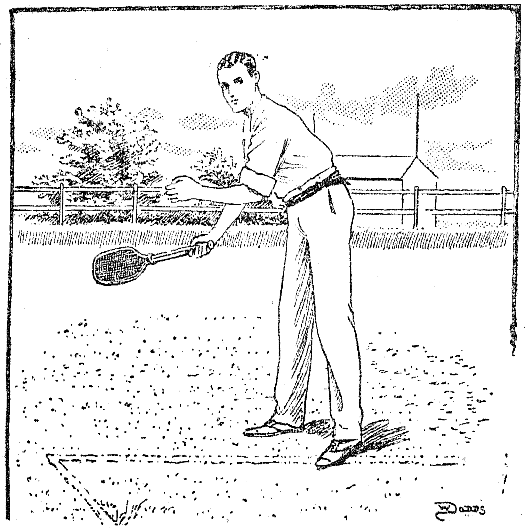


The courts should be laid off with white paint or white wash, and have a large margin of free space around them—12 feet on each side and 21 at each end have been suggested. For the posts A A *ash* is the best wood. These posts should be 2 inches in diameter and rise $3\frac{1}{2}$ feet above the ground; they ought to have a three-toed foot and be made firm with iron pegs or by insertion in a standard. The net, made of strong twine, with square meshes of about $1\frac{1}{2}$ inch of side, should be fastened by having brass rods threaded through the end squares and these fixed securely to the posts. It should stretch from the ground to the top of the posts and be kept stent by a strong cord, that it may not so sag as to get lower than 3 feet at the middle. The rackets used are similar in shape to ordinary tennis, but they are often somewhat shorter in the handle and lighter in the make. The balls are made of hollow india-rubber, $2\frac{1}{2}$ inches in diameter, and about an $\frac{1}{8}$ less than 2 ounces in weight. It is recommended that in fine weather balls covered with white cloth should be used. In addition to the implements of the game here mentioned, it is, in general, advisable that there should be at hand a *drill*, for boring such holes as are required to be pierced in the ground for the net-posts and poles; a *hammer*, for driving in and fixing the poles; *guy ropes* with *runners* or pulleys, to keep the poles in an upright position; *pegs*, to mark out boundaries, prevent the net from flapping in the wind, &c.; a *brush* and *chalk*, to rule-off the boundaries of the court—as the outline for base-ball or the cricket-field crease is marked. Some players use lengths of white tape edged with small rings, which may be pegged into the ground. These are very useful, being easily placed and removed. Lawn-tennis-court markers have been invented which, on being filled with thoroughly dissolved whiting, can be driven over the ground to form the outlines of the courts. Japanned bat-cases are much used for preserving bats, and racket presses are found useful for keeping the bats in shape and proper tension when not in use.

In a single-handed game, the players toss as to which will serve. The loser chooses the side of the net on which he will play. Standing with one foot outside of (the other within) the base-line of his court, the *server* delivers the ball from his court, over the net, into the court of the *striker-out*. He, standing within his court, awaits the coming of the ball, lets it bound once, and then, before it reaches the ground again, strikes it back over the net so that it shall fall into the court of the *striker-in*. The ball is not in play until it has been thus served, not only into the rival's court, but so as to strike the ground—*i.e.*, drop "within (1) the service-line, (2) the half-court line, and (3) the side line of the court *diagonally* opposite to that from which it was served, or any such line." The ball returned by the striker-out is only good when it (1) goes over the net and (2) drops within the server's court. The play is to keep the ball bounding and rebounding from court to court in this way until one or other fails to keep the ball in play. A failure gives a score to the opponent. *Two consecutive faults* also give a score to an opponent. A server's faults are, serving a ball which drops (1) in the net, or (2) beyond the service line, or (3) out of court, or (4) into the wrong court. The defaulter shall serve again from the same court as that from which the fault was served. It is not a fault if the ball shall merely touch the net. A stroke is won by the server if his opponent (1) *volley* the service—*i.e.*, strike the ball before it touches the ground, (2) does not return the service and keep the ball in play, (3) returns the service or ball in play so that it drops outside of any of the boundary lines of the court of his opponent, (4) allows the ball to touch anything he wears or carries (except his racket while he is striking with it), or (5) if he touch or strike the ball in play more than once with his racket. At the end of each game the striker-out becomes *server*, and the server *striker-out*, and so on till a set of games is finished. Each successive service is given from the alternate court to that from which the previous service has been given. The rules of Lawn Tennis seem very intricate when read; they are not really hard to understand when seen in operation. A careful study of the game between two (or more) good players, will teach much more surely and speedily than the most careful and expressive writing.

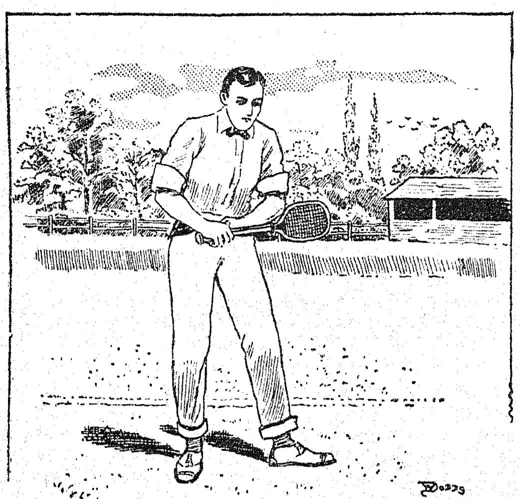
People who have been accustomed to play at Rackets find the play in Lawn Tennis come easy to their hand very speedily. Upon the holding of the racket depends, in a great measure, the making of good strokes. No rules can suffice to teach how to grasp the racket—so much depends on size of hand,

pliability of muscle, strength of play of wrist, and sweep of arm from shoulder to fingers. Only avoid a play which requires much angularity of elbow—bringing it into a V-shape when striking, for an elbow stroke is feeble and loses directness. Keep the wrist straight, the racket-face towards the ball in forehand play, and the rough face towards it in backhand play. Some authorities recommend the holding of the racket so that the grip may be the same in



Forehand Stroke.

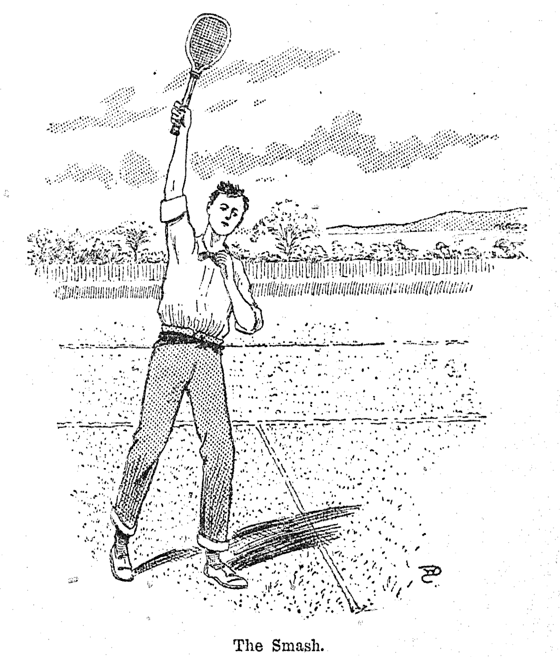
forehand and in backhand strokes; others that the grip should be changed. This is not a matter for precept; it is one for practical experience. For a *forehand* stroke the generally favourable position to assume is—the left foot slightly advanced, the main weight of the body being supported on the right limb. In the act of striking, the body leans forward; the weight is placed on the left foot; the knee of



Backhand Stroke.

the left leg is bent; the spring of the right foot is utilized; the racket is held back behind the shoulder—less or more, according to the force intended to be used—and the whole arm is slung outwards with its muscular force measured and attuned to make the stroke with calculated energy. Effective players sometimes step forward with the left foot bent—this is apt to unsteady the stroke. For a *backhand* stroke the right foot is advanced; the transfer of weight is from the left to the right foot; the body is turned sideways, and the arm swung clear and true to the hit. Do not, as some do, swing the left arm about—that destroys the requisite muscular concentration of the stroke. In service, as the front foot must be on the base line, it is safest—to avoid a "foot fault"—to put the toe on that line before serving.

The base-line or service stroke is the one of which the learner must first make sure—faults in it are so inexcusable. The returning player need not wait till the ball served has bounded on the floor before he returns it; he may volley. A *volley* is a stroke made while the ball is in motion, before it has touched and rebounded. In such a stroke, however, it is not enough that the racket should hit the ball to make an effective return; the racket must hit the ball and a distinct stroke must be made. In taking a volley, a step forward with the left foot should be made for a forehand stroke, and for a backhand stroke a forward step with the right foot. Volleys may be either—(1) pushes, or (2) hits. When a ball is coming down the line just above the net, and it is the player's best plan to return it very much as it approaches, he should knit up his elbow, stiffen his wrist, place the racket horizontally across his body, and move it on that plane which will meet



The Smash.

the advancing ball, and push it by back or fore hand, as seems likeliest to return it safely to its sender. When the ball is played higher the blade of the racket is moved speedily backward, and a stroke is given just as you would give a ground stroke of similar altitude. When the volley to be taken is low, the player must stoop to get the racket under, in order that it may lift the ball. When the ball comes short across the court from near the top of the net, the blade of the racket is to be raised a little higher than the hand; then, by a sharp wrist-turn, is set to an angle, and so strikes the ball. The *smash* is a sharp volley, used when the ball is very near the net and when it is necessary to catch the ball with the racket, otherwise a good stroke could not be played. It sometimes requires the player to jump up off his feet to secure the carrying of the ball over the net. A *half-volley* is one taken just when the ball is leaving the ground on its rise. A *lob* is a stroke taken either (1) to gain time when in a difficulty—when the ball is sent as high and as near to the base-line as one can, or (2) to drive the antagonist back towards the base-line that the play may become freer.

As to strokes, which always offer themselves at various heights, one must take them as best he may; but a skilful hand gets into the way of watching the play of the ball, and takes it at an advantageous moment; and that is, variably for height